DOCUMENT RESUME

ED 124 416 SE 020 846

AUTHOR	Hooper, Frank H.; And Others
TITLE	A Representative Series of Piagetian Concrete Operations Tasks. Theoretical Paper No. 57.
INSTITUTION	Wisconsin Univ., Madison. Research and Development Center for Cognitive Learning.
SPONS AGENCY	National Inst. of Education (DHEW), Washington, D.C.
REPORT NO	WRDCCL-TP-57
PUB DATE	Sep 75
CONTRACT	NE-C-00-3-0065
NOTE	100p.; Report from the Project on Children's Learning and Development
EDRS PRICE	MF-$0.83 HC-$4.67 Plus Postage.
DESCRIPTORS	*Cognitive Development; Elementary Education; Elementary School Mathematics; Learning; *Learning Theories; Logical Thinking; Longitudinal Studies; Mathematical Concepts; *Mathematics Education; *Research; *Test Construction; Tests
IDENTIFIERS	*Piaget (Jean)

ABSTRACT

As an integral step in a comprehensive, four year longitudinal analysis of concept development, a series of logical concept tasks based upon Piagetian theory, and suitable for administration to individuals five years of age or older, are described. The developmental focus was the logical groupements associated with the concrete operations period of middle-childhood. Sixty-four binary choice items were devised; one half of these assessed the operation of logical composition while the remainder assessed the inverse operation and reciprocal operation. In addition, complimentary concrete operations tasks, adapted from the procedures of previous normative investigations, were administered. These included dichotomous sorting, some-all understanding, class inclusion, cardinality, combinatorial reasoning, serial ordering, addition, and correspondence, transitive inference, and conservation of length, weight, and number. A sample of 180 children (equal numbers of kindergarten, and third and sixth grade male and female subjects) received the concept task series. Significant sex differences and order of presentation effects were generally absent. As anticipated, grade-level main effects were significant for the great majority of the tasks. Psychometric analyses were conducted, and it was concluded that the task series was a generally reliable assessment of logical reasoning. (Author/SD)

Documents acquired by ERIC include many informal unpublished materials not available from other sources. ERIC makes every effort to obtain the best copy available. Nevertheless, items of marginal reproducibility are often encountered and this affects the quality of the microfiche and hardcopy reproductions ERIC makes available via the ERIC Document Reproduction Service (EDRS). EDRS is not responsible for the quality of the original document. Reproductions supplied by EDRS are the best that can be made from the original.

ED124416

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

THEORETICAL PAPER NO. 57

a representative series of piagetian concrete operations tasks

SEPTEMBER 1975

WISCONSIN RESEARCH
AND DEVELOPMENT
CENTER FOR
COGNITIVE LEARNING

MAR 26 1976

Theoretical Paper No. 57

A REPRESENTATIVE SERIES OF PIAGETIAN CONCRETE OPERATIONS TASKS

by

Frank H. Hooper, Charles J. Brainerd, and Thomas S. Sipple

Report from the Project on
Children's Learning and Development

Frank H. Hooper
Principal Investigator

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
Madison, Wisconsin
September 1975

PERMISSION TO REPRODUCE THIS COPYRIGHTED MATERIAL HAS BEEN GRANTED BY

NIE

TO ERIC AND ORGANIZATIONS OPERATING UNDER AGREEMENTS WITH THE NATIONAL INSTITUTE OF EDUCATION. FURTHER REPRODUCTION OUTSIDE THE ERIC SYSTEM REQUIRES PERMISSION OF THE COPYRIGHT OWNER.

© 1975 - The Regents of the University of Wisconsin System for the Wisconsin Research and Development Center for Cognitive Learning.
Copyright is claimed only during the period of development, test, and evaluation, unless authorization is received from the National Institute of Education to claim copyright on the final materials. For the current copyright status, contact either the copyright proprietor or the National Institute of Education.

Published by the Wisconsin Research and Development Center for Cognitive Learning, supported in part as a research and development center by funds from the National Institute of Education, Department of Health, Education, and Welfare. The opinions expressed herein do not necessarily reflect the position or policy of the National Institute of Education and no official endorsement by that agency should be inferred.

Center Contract No. NE-C-00-3-0065

WISCONSIN RESEARCH AND DEVELOPMENT CENTER FOR COGNITIVE LEARNING

MISSION

The mission of the Wisconsin Research and Development Center for Cognitive Learning is to help learners develop as rapidly and effectively as possible their potential as human beings and as contributing members of society. The R&D Center is striving to fulfill this goal by

- conducting research to discover more about how children learn
- developing improved instructional strategies, processes and materials for school administrators, teachers, and children, and
- offering assistance to educators and citizens which will help transfer the outcomes of research and development into practice

PROGRAM

The activities of the Wisconsin R&D Center are organized around one unifying theme, Individually Guided Education.

FUNDING

The Wisconsin R&D Center is supported with funds from the National Institute of Education; the Bureau of Education for the Handicapped, U.S. Office of Education; and the University of Wisconsin.

ACKNOWLEDGMENTS

The authors wish to acknowledge the cooperation and assistance provided by Lyman Olson, administrative assistant, Virginia Carlson, Ralph Crowe, Arthur Engel, and Peter Peterson, elementary school principals, and the staff and students of Royce, Waterman, Merrill, and McNeel elementary schools of the Beloit, Wisconsin, Public School System.

We thank Spencer Swinton, Educational Testing Services, Princeton, New Jersey, for assistance regarding statistics and measurement. In addition, we thank Craig Hougum for providing computer programming services. We also wish to acknowledge Susan Anderson, Nikki DeFrain, Arthur Gonchar, Richard Stern, and Thomas Toniolo for administering the tasks.

TABLE OF CONTENTS

Chapter		Page
	Acknowledgments	iv
	List of Tables	vii
	List of Figures	ix
	Abstract	xi
I	Introduction	1
II	The Concrete Operations Task Series	7
	The Logical Groupements Tasks.	8
	Additional Classificatory Measures	16
	Additional Relational Measures	17
	Conservation Tasks	18
	Memory Tasks	19
III	Initial Psychometric Analyses	21
	References	31
	Appendices	
	A - Complete Administration and Scoring Procedures for the Concrete Operations Task Series	35
	B - Inter-Item Analyses (Point Bi-Serial Correlation Coefficients) for the Groupements Tasks.	79

LIST OF TABLES

Table		Page
1	Sampling Design for the Longitudinal Study	2
2	Means and Standard Deviations for the Four Class Groupements Tasks from the Initial Assessment Year's Results	22
3	Means and Standard Deviations for the Four Relations Groupements Tasks from the Initial Assessment Year's Results	23
4	Means and Standard Deviations for the Class Inclusion, Combinatorial Reasoning, Auditory Memory Span Test, Auditory Sequential Memory Test and Visual Orientation Memory from the Initial Assessment Year's Results	24
5	Means and Standard Deviations for the Seriation (Combined Scores), Length Transitivity, and Weight Transitivity Tasks from the Initial Assessment Year's Results	25
6	Means and Standard Deviations for the Some-All, Dichotomous Sorting, and Cardinality Tasks from the Initial Assessment Year's Results	26
7	Means and Standard Deviations for the Number Conservation, Length Conservation, and Weight Conservation Tasks from the Initial Assessment Year's Results.	27
8	Hoyt Reliabilities for Various Groupement Subscales for Two Samples, Combining Kindergarten, Third Grade, and Sixth Grades (N = 180) for the U.S. Sample and Combining Kindergarten, and First, Second, and Third Grades (N = 255) for the Canadian Sample	28
9	Hoyt Reliabilities for Various Conservation Subscales Combining Kindergarten and Third Grades (N = 120) for the U.S. Sample	29
10	Hoyt Reliabilities for the Seriation, Transitivity of Length, and Transitivity of Weight Subscales Combining Kindergarten and Third Grades (N = 120) for the U.S. Sample	30

Table		Page
11	Hoyt Reliabilities for the Some-All and Cardinality Tasks Combining Kindergarten and Third Grades (N = 120) for the U.S. Sample	30
12	Hoyt Reliabilities for Subscales of the Class Inclusion Task Combining Kindergarten and Third and Sixth Grades for the U.S. Sample	30
B-1	Point Bi-Serial Correlation Coefficients for All Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	80
B-2	Point Bi-Serial Correlation Coefficients for All Class Groupement (I-IV) Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	81
B-3	Point Bi-Serial Correlation Coefficients for All Relational Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	82
B-4	Point Bi-Serial Correlation Coefficients for All Composition Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	83
B-5	Point Bi-Serial Correlation Coefficients for All Inversion/ Reciprocity Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	84
B-6	Point Bi-Serial Correlation Coefficients for All Class Composition Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	85
B-7	Point Bi-Serial Correlation Coefficients for All Class Inversion Groupement Items Combining Kindergarten and Sixth Grade Subsamples (N = 180)	86
B-8	Point Bi-Serial Correlation Coefficients for All Relational Composition Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	87
B-9	Point Bi-Serial Correlation Coefficients for All Relational Reciprocity Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	88
B-10	Point Bi-Serial Correlation Coefficients for All Groupement I Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	89

Table		Page
B-11	Point Bi-Serial Correlation Coefficients for All Groupement II Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	90
B-12	Point Bi-Serial Correlation Coefficients for All Groupement III Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	90
B-13	Point Bi-Serial Correlation Coefficients for All Groupement IV Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	90
B-14	Point Bi-Serial Correlation Coefficients for All Groupement V Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	91
B-15	Point Bi-Serial Correlation Coefficients for All Groupement VI Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	91
B-16	Point Bi-Serial Correlation Coefficients for All Groupement VII Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	92
B-17	Point Bi-Serial Correlation Coefficients for All Groupement VIII Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)	92

LIST OF FIGURES

Figure		Page
1	Triangular stimuli used in Groupements I, II, and III tasks	10
2	Circular stimuli used in Groupements I, II, and III tasks	11
3	Stimulus 1 used in Groupement IV task	12
4	Stimulus 2 used in Groupement IV task	13

ABSTRACT

As an integral step in a comprehensive, four year longitudinal analysis of concept development, a series of logical concept tasks based upon Piagetian theory, and suitable for administration to individuals five years of age or older, are described. The developmental focus was the logical groupements associated with the concrete operations period of middle-childhood, primary addition of classes, secondary addition of classes, bi-univocal multiplication of classes, co-univocal multiplication of classes, addition of asymmetrical relations, addition of symmetrical relations, bi-univocal multiplication of relations, and co-univocal multiplication of relations, respectively. Sixty-four binary choice items were devised; one half of these assessed the operation of logical composition while the remainder assessed the inverse operation (classificatory cases) and reciprocal operation (relations cases). In addition, complimentary concrete operations tasks, adapted from the procedures of previous normative investigations, were administered. These included dichotomous sorting, some-all understanding, class inclusion, cardinality, combinatorial reasoning, serial ordering, addition, and correspondence, transitive inference, and conservation of length, weight, and number.

A sample of 180 children (equal numbers of kindergarten, and third and sixth grade male and female subjects) received the concept task series. Significant sex differences and order of presentation effects were generally absent. As anticipated, grade-level main effects were significant for the great majority of the tasks (the only exception was length transitivity). Initial psychometric analyses utlizing coefficient alpha (Hoyt reliability coefficients and associated standard errors of measurement) indicated a generally satisfactory level of internal consistency for the present task series. The Hoyt reliability values for the various groupements comparisons (including a separate sample of Canadian children) ranged from .62 to .91. It was concluded that the concept task series provides a generally reliable assessment of logical reasoning during the middle-childhood years.

I

INTRODUCTION

The purpose of this paper is to present a resume of a Piagetian concrete operations task array which is currently undergoing development and evaluation. These task formats were designed for utilization in an ongoing longitudinal study of children's cognitive development and concept learning (Hooper & Klausmeier, 1973). It is hoped that a detailed report of the theoretical rationale, psychometric characteristics, and administrative procedures will enable other researchers to consider the employment of these measures as indices of Piagetian logical thought during the middle childhood years.

In conjunction with a series of concept tasks derived from the Conceptual Learning and Development (CLD) model (Klausmeier, Ghatala, & Frayer, 1974), the present array of Piagetian measures is the focus of a longitudinal assessment of children aged 5 to 15 years. Representative samples of kindergarten, third, and sixth grade children (30 boys and 30 girls at each age-grade level) from a school system in a Midwestern city (1972 population: 35,729) were initially assessed in the spring of 1973. The 156 continuing participants were retested in the spring of 1974. The 1975 core longitudinal sample consisted of 146 subjects. In addition, testing effect control groups (N = 24 at each grade level) were drawn from the original cohort samples and tested initially in 1974, while separate control samples were employed in 1975. The general sampling-assessment design is presented in Table 1. All the children also received a series of group administered concept tasks derived from the CLD model dealing with mathematics (equilateral triangle), language (noun), and science (tree and cutting tool).

The detailed theoretical rationale underlying the present Piagetian task series has been previously discussed (e.g., Brainerd, 1972, 1973a, 1973b; Brainerd & Hooper, 1975; Flavell, 1963; Hooper & Klausmeier, 1973; Inhelder & Piaget, 1964; Kofsky, 1963, 1966; Piaget, 1960, 1970a, 1972; Weinreb & Brainerd, 1975). Reports detailing the initial research results are currently in progress (e.g., Dihoff, 1975; Gonchar, 1975; Hooper, Swinton, & Sipple, 1975; Toniolo & Hooper, 1975). The background discussion presented here will therefore, of necessity, be brief.

For Piaget the process whereby the individual acquires knowledge concerning external objects (including social objects), himself, and salient self/object interrelationships is an inevitable product of a dialectical interactionist system (Piaget, 1970a, 1970b). The individual's actions are the basis for the realization of self and the construction of the external world; thus neither component can be defined independently of the other since the changing structure of each is mutually dependent upon the dialectical perspective. Piaget defines intelligence, the highest form of biological adaptation, as follows:

TABLE 1

Sampling Design for the Longitudinal Study

(Table entries are approximate mean ages)

	Time of Measurement			
Cohort	1973	1974	1975	1976
1967	6 N = 60) ⟶ [Kindergarten]	7 (N = 48) ⟶	8 (N = 46) ⟶	9
1967		7 (N = 24)		
1967			8 (N = 21)	
1967				
1964	9 (N = 60) ⟶ [Third Grade]	10 (N = 54) ⟶	11 (N = 50) ⟶	12
1964		10 (N = 24)		
1964			11 (N = 22)	
1964				
1961	12 (N = 60) ⟶ [Sixth Grade]	13 (N = 54) ⟶	14 (N = 50) ⟶	15
1961		13 (N = 24)		
1961			14 (N = 24)	
1961				

. . . the form of equilibrium towards which all the structures arising out of perception, habit, and elementary sensorimotor mechanism tend . . . [and further] the most plastic and at the same time the most durable structural equilibrium of behaviour, [intelligence] is essentially a system of living and acting operations [Piaget, 1960, pp. 6-7].

The term concept denotes qualitatively distinct entities and associated processes for the Piagetians as contrasted with the typical learning theorist (Beilin, 1971; Elkind, 1969; Klausmeier & Hooper, 1974).

> The reference point for the term concept varies in Piaget's theory depending upon the general developmental period in question. Thus, in the infant and very young child concepts are denoted by the sensorimotor schemes set in the context of external actions. The gradual appearance of a stable object-permanence concept, that external objects exist independently of the infant's actions upon them or spatio-temporal relationship with them, is an example of a sensorimotor conceptual acquisition.
>
> > In the older preoperational child, concepts are beginning to be interiorized, that is, in part dissociated from particular actions, but yet dominated by personal ("egocentric") viewpoints; in this sense they are "subjective," unstable concepts. Eventually stable "objective" concepts are attained; at the point that they become fully interiorized action schemes--Piaget calls them operations [Furth, Youniss, & Ross, 1970, p. 37].
>
> It is through this action-based operativity that genuine knowledge is acquired. "Operativity, which may involve the use of sensory and perceptual data, leads to the construction of knowledge, while perceptual and sensory data per se do not [Beilin, 1971, p. 99]."

Operativity in the strict sense only becomes possible during the middle childhood years. It is during this time that the child's cognitive activities become organized into coherent and integrated systems. The term operation is used to refer to these systems both as something the child has at his disposal (i.e., activities which the child is capable of performing) and as something the child typically does (Furth, 1969). Concrete operations are internalized representations of coordinated actions which are, themselves, organized into larger coordinated systems called groupings or groupements. Viewed as something the child does, operations include the logico-mathematical activities of adding, subtracting, dividing, setting terms in correspondences as in the cases of classes and relations, and the infralogical activities (anchored to a specific spatio-temporal context) which deal with quantity, measurement, space, and time concepts (cf. Flavell, 1963, p. 166). Viewed as something the child has, operations must be considered as parts of a higher-order structural organization. As Flavell has stated:

> One cannot really grasp the concept of class without understanding what a classification system entails, because the single class is only an abstraction from the total system. This is the central meaning of Piaget's holism in the domain of cognitive operations: the isolated operation can never be the proper unit of analysis, because it gains all its meaning from the system of which it is a part. A given operation, put into concrete effect in the here and now, always presupposes a structured system which includes other,

> related operations, for the moment latent and inactive but always potentially actualizable themselves and, above all, always a force governing the form and character of the operation which is momentarily on stage [Flavell, 1963, p. 167].

It is these supraordinate structures, the [so called] logical operations groupements, which are said to interrelate and subsume all directed thought during the middle childhood period. Four of the groupements are concerned with [operations on] logical classes, and four complementary cases deal with [operations on] logical relations. The most important of these include primary addition of classes (as evidenced, for example, in the class inclusion problem), bi-univocal multiplication of classes (as shown in matrix completion or class intersection problems), addition of asymmetrical relations (as evidenced in seriation and transitive inference tasks, e.g., the conclusion that A must be less than C, on some dimension, if shown that A<B and B<C), and bi-univocal multiplication of relations (as assessed, for example, in the serial correspondence and double seriation matrix tasks).

The present investigation has as its explicit goal an admittedly formidable research objective, i.e., the empirical assessment of the behavioral consequences of Piaget's logical model as represented in the concrete-operational groupements of the middle childhood years. Since the various logical groupements are theoretically predicted to emerge in parallel or concomitant fashion, developmental synchrony is anticipated for all the higher-order classificatory and relational conceptual acquisitions. This forms the basis of one major implication directly generated by the Piagetian logical structure construct--that of within-stage correspondence (cf. Brainerd, 1973b; Flavell, 1970, 1971; Hooper, 1973; Wohlwill, 1963). Relatively uniform performances should be found for task situations (equated for general item difficulty) designed to assess behaviors derived from common structural components. Thus, for example, equivalent tasks measuring class, relation, and natural number concept proficiency should show similar congruent developmental patterns (initial emergence, stabilization-generalization, and final mastery) according to orthodox Piagetian theory [Brainerd, 1972].

The antithetical corollary to the stage-correspondence postulate is, of course, within-stage sequential linkages, i.e., the prediction that mastery of certain less complex task-specific behaviors is a logical and genetic precursor of subsequent higher-order abilities. Certain empirically demonstrated cognitive-developmental sequences or asynchronies are difficult to reconcile within the Piagetian

system as it is conventionally interpreted (cf. Flavell, 1972, for a noteworthy description and analysis of developmental sequences) [Hooper & Klausmeier, 1973, pp. 13-16].

II

THE CONCRETE OPERATIONS TASK SERIES

The present task array was designed to ensure a certain minimal degree of across-subject and across-task standardization while maintaining essential comparability with the earlier Piagetian concrete operations concept assessment research. All measures were individually administered and an attempt was made to retain the desirable flexibility features of the méthode clinique. Thus, following the establishment of essential rapport with the subject, the task settings were administered in a relaxed, game-like atmosphere intended to be nonanxiety producing. No explicit corrective reinforcement was introduced except in the initial warm-up sessions. Questions were restated if the child's responses were ambiguous or if an obvious misunderstanding of the criterial question was evident. The tasks were presented in three separate sessions[1] as follows:

Session One: (A) Seriation task series, (B) Conservation of number, (C) Arithmetic operations (addition and subtraction)[2], (D) Cardinality, and (E) Dichotomous sorting.[3]

Session Two: (A) Memory tasks (auditory memory span [word series], auditory sequential memory [digit span], and visual orientation memory), (B) Groupement tasks, (C) Combinatorial reasoning, and (D) "Some-all" relationships.

Session Three: (A) Conservation and Transitivity tasks series[4], and (B) Class inclusion task.

---

[1]Note that only a partial task array, e.g., memory tasks, groupement tasks, combinatorial reasoning, and class inclusion, was administered to the sixth grade and subsequent older subjects in a single session.

[2]The arithmetic operations task (Brainerd, 1973a) consisted of 16 incomplete addition equations, e.g., "How many apples is four apples plus three apples?", and 16 incomplete subtraction equations, e.g., "How many apples is five apples minus three apples?". The items were presented in written form and read aloud to the child. The subject was permitted three minutes to complete the entire set of 32 items.

[3]The various tasks in the initial session were presented in one of the following four orders of presentation: E, D, A, B, C; A, C, D, B, E; E, B, D, C, A; C, B, A, D, E.

[4]The conservation and transitivity measures consisted of: conservation of length (identity and equivalence task formats), conservation of weight (identity and equivalence task formats), transitivity of length, and transitivity of weight. Following a "warm-up" exercise to ensure an understanding of the criterial reference terms, the identity, equivalence, and transitivity tasks were presented in one of six counter-balanced orders of presentation. The length cases always preceded the weight cases.

Brief descriptions of the administration procedures and stimulus materials employed in each of the concrete operations tasks are presented below. For complete administration procedures and associated scoring protocols see Appendix A.

THE LOGICAL GROUPEMENT TASKS

Piaget employs the term groupement to describe the structural "unit" of the child's reasoning typical of the middle-childhood age interval. The term signifies "that these structures are syntheses of the common group and lattice structures of abstract algebra [Brainerd, 1972, p. 4]." Four of the cases deal with classes and four concern relational understanding. As Brainerd observed:

> Piaget contends that a given structure S is engendered by either a cognitive operation and its inverse--if S is one of the four "class" groupements--or by a cognitive operation and its reciprocal--if S is one of the four "relational" groupements. In theory, the notion of "operation" can here be taken to mean almost any internalizable property of overt action. In practice, however, the notion may be restricted to the set-theoretic operations of union and intersection and the arithmetic operations of addition and multiplication. Thus, each class groupement owes its existence to the fact that the cognizer is capable of simultaneously uniting and subtracting classes, while each relational groupement owes its existence to the fact that the cognizer is instantaneously aware of the reciprocal implications of the equivalence and difference relations produced by arithmetic addition and multiplication. To illustrate, the capacity simultaneously to add two subordinate classes to yield a superordinate class and to subtract one subordinate class from the superordinate class to yield the remaining subordinate class engenders a certain class groupement structure. Also to illustrate, the knowledge that A<B and B<C simultaneously implies both A<C and C>A engenders a certain relational structure. Although one may quibble with these claims about the origins of groupement structures on theoretical grounds, there is no denying their obvious empirical implication: If one wishes to conduct research on these structures, then one most certainly will have to focus on the unions and intersections of hierarchical classes and their inverses--on the one hand--and on the addition-multiplication of equivalence-difference relations and their reciprocals--on the other [Brainerd, 1972, p. 5].

Each groupement structure may be characterized by formal properties which include the operations of composition, reversibility, general identity, special identity, and associativity. The initial operation of composition, e.g., the union of classes, and its inverse (for the class cases) or its reciprocal (for the relations cases), have been utilized in the present task settings. The total task array consists of 64 two-choice judgments, eight for each of the separate groupements. Half the items deal with the composition operation and

the remainder assess the reverse operation. The stimuli for the class groupements (I-III) are presented in Figures 1 and 2; the stimuli for class groupement IV are shown in Figures 3 and 4.

Groupement I: Primary Addition of Classes (Score Range = 0-8)

1. In reference to triangles, some blue, some yellow, some red, and some both yellow and red (see Figure 1), the S is asked whether the triangles of some specific color are the same (more) in number as all the triangles. The logical operation characterizing the psychological process is the composition (addition) of hierarchical primary classes A (triangles with yellow on them) + A' (triangles without yellow on them) = B (triangles). 4 trials.
2. In reference to the same stimuli, the S is asked whether there would be any members of the superordinate class remaining if all the members of the subordinate class were removed. The logical operation characterizing the psychological process is the inversion (subtraction) of hierarchical primary classes B (triangles) - A (triangles with yellow on them) = A' (triangles without yellow on them). 4 trials. (The above procedure in 1 and 2 is repeated with circles, see Figure 2.)

Groupement II: Secondary Addition of Classes (Score Range = 0-8)

1. In reference to the same stimuli used in Groupement I, the S is asked whether the triangles of a different specific color are the same (more) in number as all the triangles. The logical operation characterizing the psychological process is the composition (addition) of hierarchical secondary classes A_2 (triangles with red on them) + A_2' (triangles without red on them) = B (triangles). 4 trials.
2. In reference to the same stimuli, the S is asked whether there would be any members of the superordinate class remaining if all the members of a subordinate class were removed. The logical operation characterizing the psychological process is the inversion (subtraction) of hierarchical secondary classes B (triangles) - A_2 (triangles with red on them) = A_2' (triangles without red on them). 4 trials. (The above procedure in 1 and 2 is repeated with circles, see Figure 2.)

Groupement III: Bi-univocal Multiplication of Classes (Score Range = 0-8)

1. In reference to the same stimuli used for Groupement I and Groupement II, the S is asked whether the figures with any amount of yellow (red) on them are the same (more) in number as the figures with both yellow and red on them. The logical operation characterizing the psychological process is the composition (multiplication) of classes where each of the component members of one class is set in one-to-one correspondence with each of the component members of

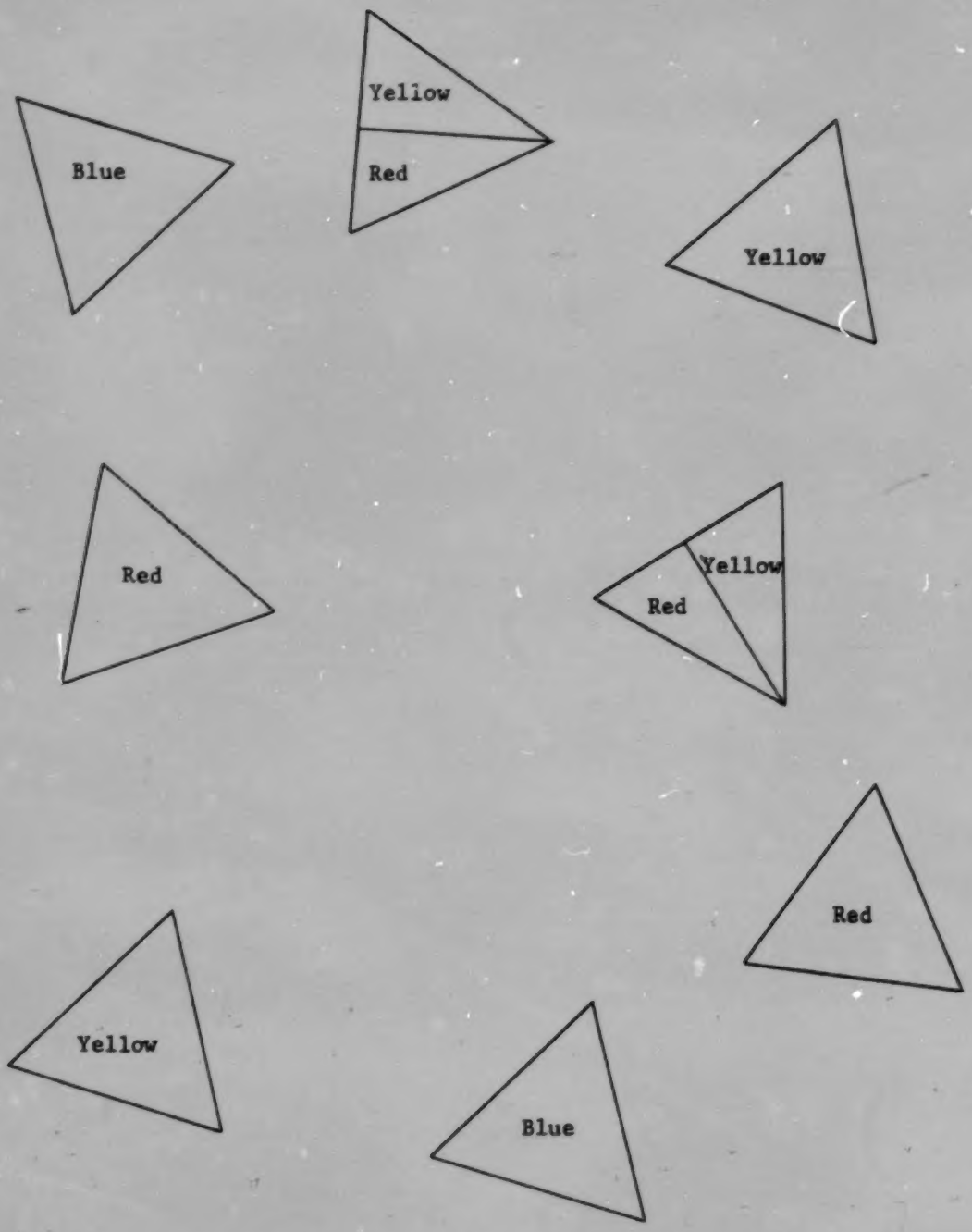


Figure 1. Triangular stimuli used in Groupements I, II, and III tasks.

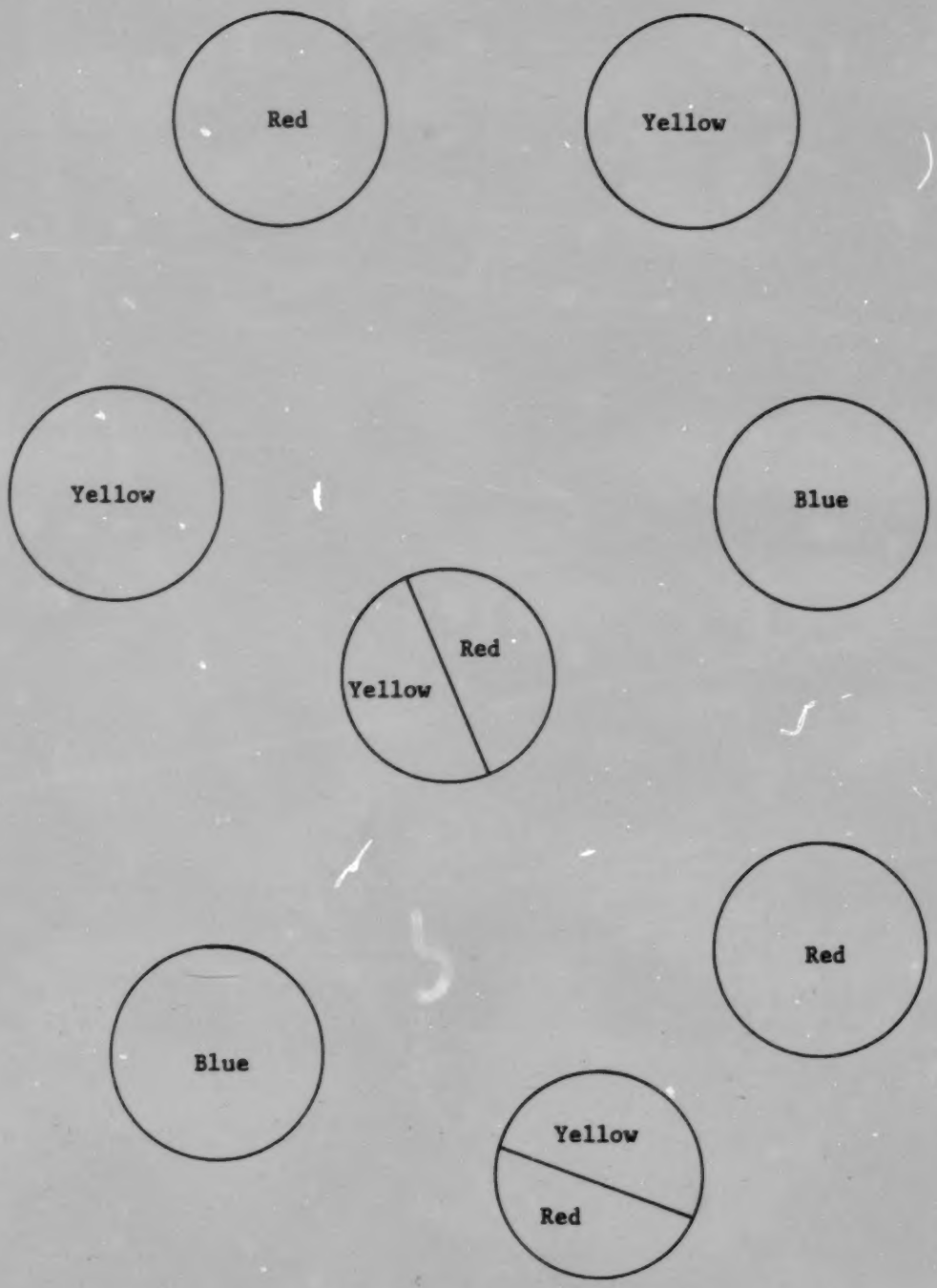


Figure 2. Circular stimuli used in Groupements I, II, and III tasks.

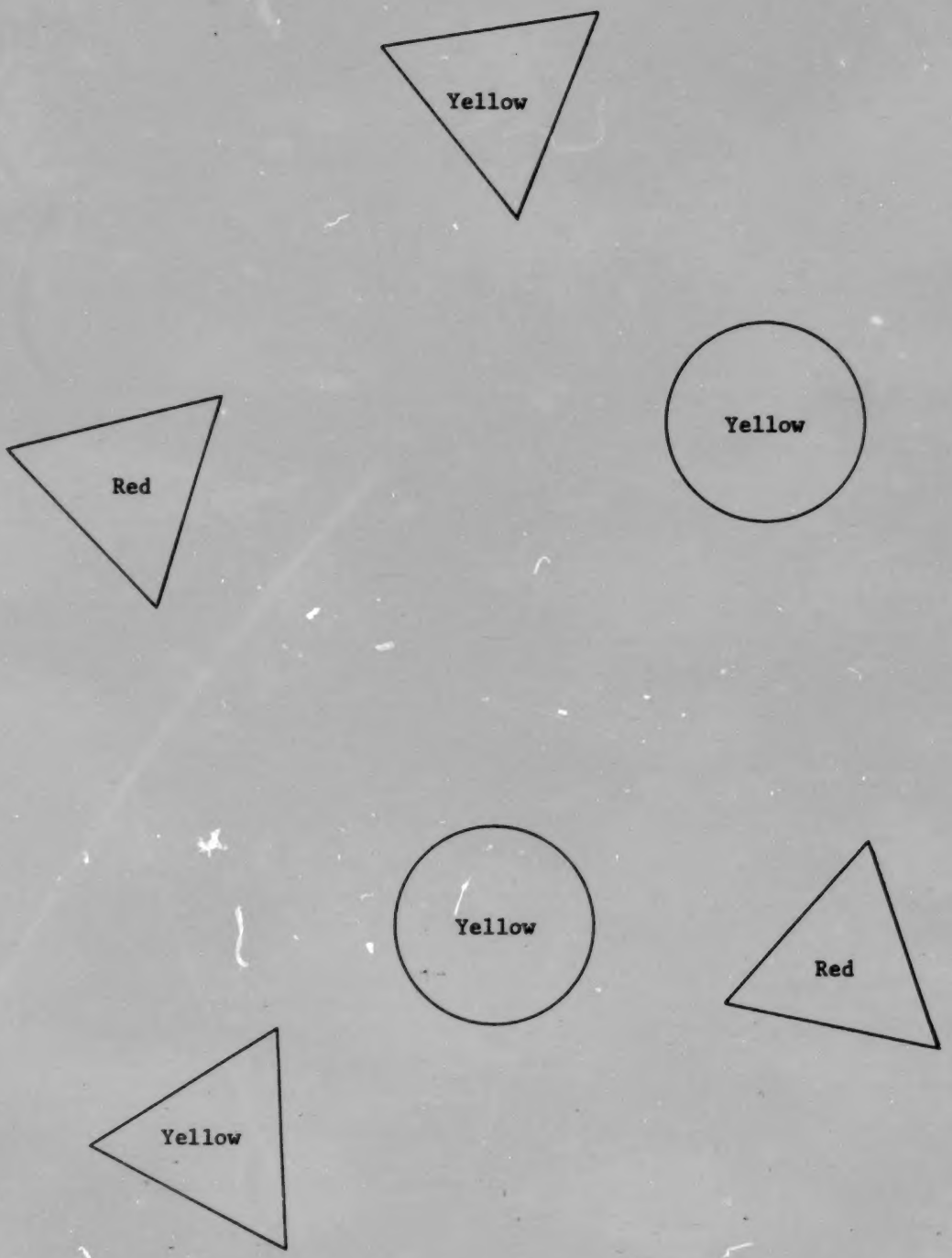


Figure 3. Stimulus 1 to be used in Groupement IV task.

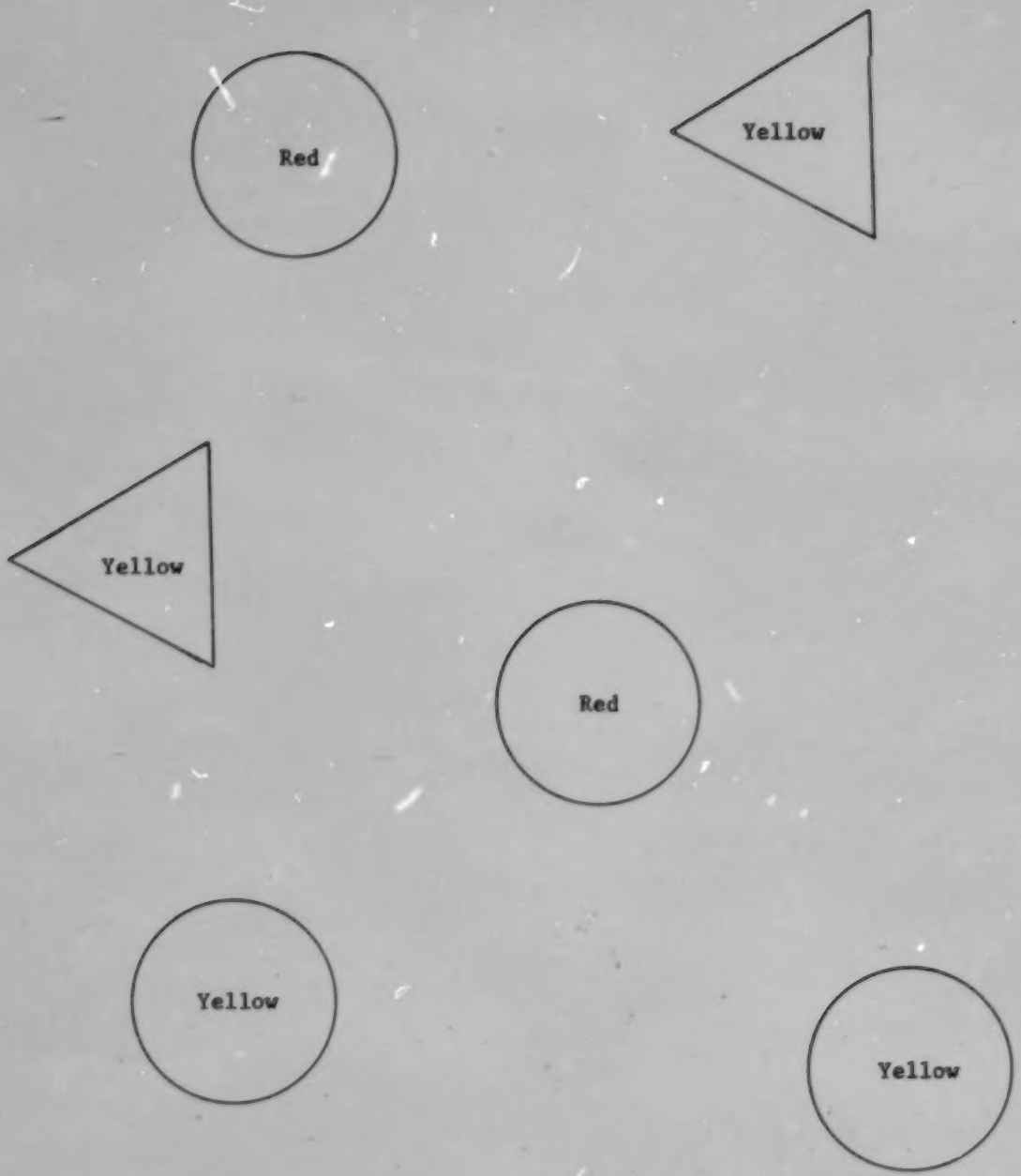


Figure 4. Stimulus 2 to be used in Groupement IV task.

a second class such that A_1 (triangles with yellow on them) x A_2 (triangles with red on them) = A_1A_2 (triangles with both yellow and red on them). 4 trials.

2. In reference to the same stimuli, the S is asked whether there would be any figures with both yellow and red on them remaining if all the circles with yellow (red) on them were removed. The logical operation characterizing the psychological process is the inversion (division) of a product class by one class such that A_1A_2 (triangles with both yellow and red on them) ÷ A_1 (triangles with yellow on them) = A_2 (triangles with red on them). 4 trials. (The same procedure in 1 and 2 above is repeated with circles, see Figure 2.)

Groupement IV: Co-univocal Multiplication of Classes (Score Range = 0-8)

1. In reference to triangles, some red, some yellow, and circles, all yellow (see Figure 3), the S is asked whether the yellow circles are the same (more) in number as the yellow figures. The logical operation characterizing the psychological process is the composition (multiplication) of classes in which one member of one class is set in correspondence with several members of a second class such that K_1 [triangles (A_1 = red, B_1 = yellow)] x K_2 [yellow (A_2 = triangles, A_2' = circles)] = A_1A_2 (red triangles) + B_1A_2 (yellow triangles) + B_1A_2' (yellow circles). 4 trials.
2. In reference to the same stimuli, the S is asked whether there would be any yellow circles remaining if all the yellow figures were removed. The logical operation characterizing the psychological process is the inversion (division) of product classes by one class such that [A_1A_2 (red triangles) + B_1A_2 (yellow triangles) + B_1A_2' (yellow circles)] ÷ [B_1 (yellow) + A_2 (triangles) + A_2' (circles)] = A_1 (red). 4 trials. (The same procedure in 1 and 2 above is repeated with Stimulus 2, see Figure 4.)

Groupement V: Addition of Asymmetrical Relations (Score Range = 0-8)

1. In reference to three sticks differing in length by a small amount, the S is shown the three sticks and told that stick A is shorter than stick B, that B is shorter than C, and is asked the existing length relationship between A and C. (The above procedure is repeated with the weight dimension.) The logical operation characterizing the psychological process is the composition (addition) of difference relations [(A → B) + (B → C) = (A → C)]. 4 trials.
2. In reference to the same stimuli, the S is shown the three sticks and told that C is longer than B, that B is longer than A, and is asked the existing length relationship between C and A. (The above procedure is repeated with the weight dimension.) The logical operation characterizing the psychological process is the reciprocity of difference relations [(A → B) + (B → C) = (A → C)] + [(C → B) + (B → A) = (C → A)] = (A = A). 4 trials.

Groupement VI: Addition of Symmetrical Relations (Score Range = 0-8)

1. In reference to three sticks each of a different color, but of the same length, the S is shown the three sticks and told that stick A equals stick B in length, that B equals C in length, and is asked the existing length relationship between A and C. (The above procedure is repeated with the weight dimension.) The logical operation characterizing the psychological process is the composition (addition) of equivalence relations $(A \leftrightarrow B) + (B \leftrightarrow C) = (A \leftrightarrow C)$. 4 trials.
2. In reference to the same stimuli, the S is shown the three sticks and told that C equals B, that B equals A, and is asked the existing length relationship between C and A. (The above procedure is repeated with the weight dimension.) The logical operation characterizing the psychological process is the reciprocity of equivalence relations $[(A \leftrightarrow B) + (B \leftrightarrow C) = (A \leftrightarrow C)] + [(C \leftrightarrow B) + (B \leftrightarrow A) = (C \leftrightarrow A)] = (A \leftrightarrow A)$. 4 trials.

Groupement VII: Bi-univocal Multiplication of Relations (Score Range = 0-8)

1. In reference to three sticks differing in both length and weight, the S is shown the three sticks and told that A is both shorter and lighter than B, that B is both shorter and lighter than C, and is asked the existing length and weight relationships between A and C. The logical operation characterizing the psychological process is the composition (multiplication) of difference relations $(A \leftrightarrow B) \times (B \leftrightarrow C) = (A \leftrightarrow C)$. 4 trials.
2. In reference to the same stimuli, the S is shown the three sticks and told that C is both longer and heavier than B, that B is both longer and heavier than A, and is asked the existing length and weight relationships between C and A. The logical operation characterizing the psychological process is the reciprocity of difference relations $(A \leftrightarrow C) \div (A \leftrightarrow C) = (A \leftrightarrow A)$ which also may be expressed as $[(C \rightarrow B) \times (B \rightarrow A)] \div (C \rightarrow A) = A \rightarrow A$. 4 trials.

Groupement VIII: Co-univocal Multiplication of Relations (Score Range = 0-8)

1. In reference to three sticks differing in length, but of the same weight, the S is shown the three sticks and told that A is shorter and is the same weight as B, that B is shorter and is the same weight as C, and is asked the existing length and weight relationships between A and C. The logical operation characterizing the psychological process is the composition (multiplication) of difference relations by equivalence relations $(A \leftrightarrow B) \times (B \leftrightarrow C) = (A \leftrightarrow C)$. 4 trials.
2. In reference to the same stimuli, the S is shown the three sticks and told that C is longer and is the same weight as B, that B is longer and is the same weight as A, and is asked the existing length and weight relationships between C and A. The logical operation

characterizing the psychological process is the reciprocity of difference relations by equivalence relations (A ↔ C) ÷ (A ↔ C) = (A ↔ A) which may also be expressed as [(C ↔ B) x (B ↔ A)] ÷ (C ↔ A) = (A ↔ A). 4 trials.

ADDITIONAL CLASSIFICATORY MEASURES

1. Dichotomies (Score Range = 0-3)

   S dichotomizes, according to one of the three dimensions, 22 pictorial stimuli varying on the dimensions of color (red or blue), shape (square or circle), and number (one or two objects per stimulus), regroups the same stimuli on another of the dimensions, and finally regroups the same stimuli on the third dimension. 3 items. Adapted from Kamii and Peper (1969).

2. Some-all (Score Range = 0-4)

   In reference to five triangles--three red and two blue--and four blue circles, the S is asked questions representing each of the following two relationships: (1) All members of a subclass are members of a higher class. 2 items. (2) Some but not all members of a higher class are members of a given subclass. 2 items. Adapted from Kofsky (1966).

3. Class Inclusion (Score Range = 0-5)

   a. In reference to triangles, three red and two blue, the S is asked whether there are more members of the superordinate class (triangles) than members of the nested subclass (red figures). 1 trial. (The above procedure is repeated using circles in another trial.)
   b. In reference to triangles--three red and two blue--and four blue circles, the S is asked whether there are more members of the superordinate class (triangles) than members of the nested subclass (red figures). 1 trial. (The procedure is repeated in another trial with the same stimuli using blue figures as the superordinate class and circles as the nested subclass.)
   c. In reference to the same stimuli used in (b), the S is asked which of the intersecting classes (blue figures or triangles) is larger. 1 trial. 5 total trials. Adapted from Kofsky (1966).

4. Combinatorial Reasoning (Score Range = 0-28)

   The S forms all possible (28) pairs of differently colored chips (eight different colors) without repeated pairs. Adapted from Goodnow (1962).

5. Cardinality Task Series (Score Range = 0-5)

   a. Cardinality I: Sets A & D
      The S judges the non-equivalence of number of two parallel rows of dots of unequal number dispersed over equal lengths. 6 items. Adapted from Brainerd (1973a).

b. Cardinality I: Sets B & C
The S judges the non-equivalence of number of two parallel rows of dots of unequal number dispersed over unequal lengths. 6 items. Adapted from Brainerd (1973a).

c. Cardinality I: Sets E & F
The S judges the equivalence of number of two parallel rows of dots of equal number dispersed over unequal lengths. 4 items. Adapted from Brainerd (1973a).

d. Cardinality II: Verbal Comparison of Numbers
The S judges the equivalence or non-equivalence of number of two pairs of single digit numbers presented verbally. 5 judgments. Adapted from Brainerd (1973a) and Gonchar (1975).

e. Cardinality II: Visual Comparison of Numbers
The S judges the equivalence or non-equivalence of two rows of dots under the following two conditions: (1) equal numbers of dots dispersed over unequal lengths, and (2) unequal numbers presented over equal lengths. 5 judgments. Adapted from Brainerd (1973a) and Gonchar (1975).

ADDITIONAL RELATIONAL MEASURES

1. Seriation Task Series (Score Range = 0-5)

   a. Serial Ordering
   The S orders (1) an array of seven sticks that differ (by one centimeter increments), in length, and (2) an array of 10 circles that differ in diameter (by three centimeter increments). Adapted from Elkind (1964).

   b. Additive Seriation
   The S inserts three additional sticks into their proper place in an existing ordered array of seven sticks. Adapted from Elkind (1964).

   c. Serial Correspondence: Matching Case
   Given a seriated array of sticks and a seriated array of circles, the S matches each member of one seriated array with the corresponding member of the other seriated array. Adapted from Coxford (1964).

   d. Serial Correspondence: Extension and Compression Cases
   The members of one seriated array are first extended, then compressed, and under each condition the S matches three members of the deformed array to the corresponding members of a second, unmanipulated, seriated array. Adapted from Coxford (1964).

   e. Serial Correspondence: Scrambled Case
   The members of one seriated array are reoriented in a scrambled fashion, and the S matches three members of the deformed array to the corresponding members of a second, unmanipulated, seriated array. Adapted from Coxford (1964).

2. Transitivity of Length (Score Range = 0-5)

   The S compares (1) one stick A to another stick B in terms of their equal lengths, (2) stick A to a third stick C in terms of their unequal lengths, and judges the inequality of length of sticks B and C. 5 judgments. Adapted from Brainerd (1973b).

3. Transitivity of Weight (Score Range = 0-5)

The S compares (1) one clay ball A to another clay ball B in terms of their equal weights, (2) clay ball A to a third clay ball C in terms of their unequal weights, and judges the inequality of weight of clay balls B and C. 5 judgments. Adapted from Brainerd (1973b).

CONSERVATION TASKS

1. Identify Conservation of Length (Score Range = 0-6)

The S (1) predicts the length of a single string to be the same if perceptually altered (3 judgments, one followed by an explanation inquiry), and (2) judges the length of the string to be the same after being perceptually altered (3 judgments, one followed by an explanation inquiry). 6 judgments. Adapted from Hooper (1969) and Brainerd (1973b).

2. Equivalence Conservation of Length (Score Range = 0-6)

The S (1) predicts the length of two perceptually equivalent strings to be equal if one were perceptually altered (3 judgments, one followed by an explanation inquiry), and (2) judges the length of the strings to be equal after one has been perceptually altered (3 judgments, one followed by an explanation inquiry). 6 judgments. Adapted from Brainerd (1973b).

3. Identity Conservation of Weight (Score Range = 0-6)

The S (1) predicts the weight of a piece of clay to be the same if perceptually altered (3 judgments, one followed by an explanation inquiry), and (2) judges the weight of the clay ball to be the same after being perceptually altered (3 judgments, one followed by an explanation inquiry). 6 judgments. Adapted from Hooper (1969) and Brainerd (1973b).

4. Equivalence Conservation of Weight (Score Range = 0-6)

The S (1) predicts the weight of two perceptually equivalent clay balls to be equal if one were perceptually altered (3 judgments, one followed by an explanation inquiry), and (2) judges the weight of the clay balls to be equal after one has been perceptually altered (3 judgements, one followed by an explanation inquiry). 6 judgments. Adapted from Brainerd (1973b).

5. Conservation of Number (Score Range = 0-7)

The S (1) predicts the number of two sets of chips to be equal if one of the sets were perceptually altered (3 judgments, one followed by an explanation inquiry), (2) judges the number of each of the sets to be equal after one has been perceptually altered (3 judgments, one followed by an explanation inquiry), and (3) judges the number of the sets to be unequal after one chip has been removed from one of the sets. 7 judgments. Adapted from Brainerd and Brainerd (1972) and Rothenberg (1969).

MEMORY TASKS

Three measures of memory ability were employed. The auditory sequential memory test (Wepman & Morency, 1973b) consisted of a forward digit series (2 to 8 digits) with two sets of differing numbers at each level (score range = 0-70). The auditory memory span test (Wepman & Morency, 1973a) consisted of a forward word series with three trials of differing word sets at each level from two to six words (score range = 0-60). The visual orientation memory test (Swinton, 1973) assessed the child's ability to recognize and identify (following a 5-second study interval) a two dimensional geometric figure (line drawing) from a pictorial array of the same figure in varying spatial orientations. There were four possible choices for each of 20 items.[5]

[5]Information regarding these copyrighted memory task materials may be obtained from Language Research Associates, Inc., 175 E. Delaware Place, Chicago, Illinois, 60611.

III

INITIAL PSYCHOMETRIC ANALYSES

Certain preliminary analyses were conducted on the initial year's cross-sectional data. The observed means and standard deviations for the kindergarten, third, and sixth grade male and female subsamples are presented in Tables 2, 3, and 4. Similar values for those tasks administered to only the kindergarten and third grade subsamples are presented in Tables 5, 6, and 7. No significant order of presentation effects were found. As anticipated, factorial analyses of variance indicated significant grade level effects for all the tasks shown in Tables 2, 3, and 4. Sex differences were significant for only one of the measures, class inclusion, where female performances were found to be superior to those of their male counterparts at all three grade levels. There were no significant grade level x sex interactions. Grade level main effects were significant for all the tasks presented in Tables 5, 6, and 7 except for the length transitivity case. While sex main effects were notably absent for all of these tasks, a significant grade level x sex interaction value resulted from a case of kindergarten female superiority and third grade male superiority for the equivalence length conservation task. Thus, children's performances on the present tasks appear to be significantly related to chronological age and generally free of notable sex biases.

Hoyt reliability coefficients, formally analogous to coefficient alpha, and associated standard errors of measurement are reported in Tables 8 through 11 (conventional reliability indices were not seen as appropriate for the dichotomies and combinatorial reasoning tasks).[6] Despite serious reservations about the appropriateness of applying conventional psychometric analyses to Piagetian concept task settings (cf. Carver, 1974), the following information may be used for general comparison purposes to more traditional ability measures. As Table 8 indicates, the Hoyt reliability values for the various groupements comparisons for all the United States and Canadian samples range from .62 to .91. For all comparisons which involved 16 or more items, the respective Hoyt values exceeded .70. Groupement task inter-item analysis values are presented in Appendix B (Tables B-1 through B-17).

Table 9 presents the reliability values for the various conservation task items. Values ranged from .87 to .95. The average Hoyt value for the conservation tasks is .91, indicating an obviously acceptable level of reliability. Table 10 presents counterpart values for the additional relational concept tasks. Due to the different logical structure of class inclusion items one through four (i.e., nested subclasses) as opposed to item five (i.e., intersecting subclasses), two subscales for computing reliability coefficients were employed (see Table 12). It may be concluded that with the exception of the Some-All task the present reliability values indicate a generally satisfactory level of internal consistency for the Piagetian task series.

---

[6] These analyses were computed using the LERTAP test analysis program, Version 2, 1974, Madison Academic Computing Center, University of Wisconsin, Madison, Wisconsin.

TABLE 2

Means and Standard Deviations for the Four Class Groupements Tasks from the Initial Assessment Year's Results (n = 30 for Each Grade/Sex Subsample)

Grade	Groupements I $\bar{X}$	I S.D.	II $\bar{X}$	II S.D.	III $\bar{X}$	III S.D.	IV $\bar{X}$	IV S.D.	Total Class $\bar{X}$	Total Class S.D.
Kindergarten										
Males	4.133	1.613	4.633	1.629	3.567	1.382	3.933	1.680	16.27	3.947
Females	4.633	1.377	5.000	2.000	3.233	1.716	3.800	1.990	16.67	5.033
Total	4.383	1.508	4.817	1.818	3.400	1.554	3.867	1.825	16.47	4.489
Third										
Males	4.533	1.252	4.800	1.349	3.133	2.096	4.567	2.285	17.03	4.916
Females	4.533	1.252	4.633	1.159	3.700	2.588	5.233	2.128	18.10	4.664
Total	4.533	1.241	4.717	1.250	3.417	2.353	4.900	2.215	17.57	4.781
Sixth										
Males	5.933	1.388	6.100	1.494	3.967	2.141	6.067	1.964	22.07	5.356
Females	6.367	1.300	6.667	1.348	4.967	2.470	6.400	2.191	24.40	5.456
Total	6.150	1.351	6.383	1.439	4.467	2.347	6.233	2.070	23.23	5.487
Combined Grade										
Males	4.867	1.609	5.178	1.619	3.556	1.914	4.856	2.165	18.46	5.384
Females	5.178	1.548	5.433	1.768	3.967	2.382	5.144	2.339	19.72	6.037
Total	5.022	1.582	5.306	1.695	3.761	.165	5.000	2.252	19.09	5.739

TABLE 3

Means and Standard Deviations for the Four Relations Groupements Tasks from the Initial Assessment Year's Results (n = 30 for Each Grade/Sex Subsample)

Grade	Groupements								Total Relations	
	V		VI		VII		VIII			
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Kindergarten										
Males	6.200	1.627	6.733	1.701	5.500	2.097	5.233	1.775	23.67	5.188
Females	6.267	1.530	6.200	1.846	5.433	2.079	4.900	1.807	22.80	5.142
Total	6.233	1.566	6.467	1.780	5.467	2.071	5.067	1.784	23.23	5.140
Third										
Males	6.833	1.464	7.833	.531	6.433	2.112	6.433	1.431	27.53	3.964
Females	7.167	1.315	7.700	1.022	6.100	2.339	6.067	1.893	27.03	3.873
Total	7.000	1.390	7.767	.810	6.267	2.216	6.250	1.674	27.28	3.894
Sixth										
Males	7.700	2.221	7.600	1.133	7.000	1.203	7.167	1.206	29.47	2.700
Females	7.067	1.721	7.633	1.159	6.833	1.440	6.900	1.398	28.43	3.874
Total	7.383	1.342	7.617	1.136	6.917	1.319	7.033	1.302	28.95	3.351
Combined Grade										
Males	6.911	1.451	7.389	1.296	6.311	1.935	6.278	1.676	26.89	4.705
Females	6.833	1.567	7.178	1.540	6.122	2.049	5.956	1.884	26.09	4.918
Total	6.872	1.506	7.283	1.423	6.217	1.989	6.117	1.785	26.49	4.817

TABLE 4

Means and Standard Deviations for the Class Inclusion, Combinatorial Reasoning, Auditory Memory Span Test, Auditory Sequential Memory Test and Visual Orientation Memory from the Initial Assessment Year's Results (n = 30 for Each Grade/Sex Subsample)

	Test									
	CI		CR		AMS		ASM		VOM	
Grade	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Kindergarten										
Males	2.133	1.480	7.000	5.620	23.800	5.555	20.930	9.191	9.067	3.270
Females	2.867	1.408	8.000	6.918	25.600	10.625	23.670	13.671	9.000	3.107
Total	2.500	1.479	7.500	6.270	24.700	8.456	22.300	11.632	9.033	3.162
Third										
Males	3.567	1.105	18.967	8.177	30.930	8.034	30.130	10.354	13.567	2.849
Females	3.867	1.196	19.833	8.726	30.430	9.930	27.170	10.578	13.567	3.646
Total	3.717	1.151	19.400	8.395	30.680	8.958	28.650	10.483	13.567	3.243
Sixth										
Males	4.167	1.117	24.167	6.154	34.270	9.490	34.100	10.065	17.133	1.676
Females	4.367	1.066	25.067	6.422	36.370	10.045	36.000	12.292	17.767	1.994
Total	4.267	1.087	24.167	6.252	35.320	9.747	35.050	11.180	17.450	1.854
Combined Grade										
Males	3.289	1.501	16.711	9.832	26.670	8.928	28.390	11.234	13.256	4.250
Females	3.700	1.369	17.633	10.266	30.800	11.018	28.940	13.187	13.444	4.662
Total	3.494	1.447	17.172	10.035	30.230	10.015	28.670	12.219	13.350	4.449

TABLE 5

Means and Standard Deviations for the Seriation (Combined Scores), Length Transitivity, and Weight Transitivity Tasks from the Initial Assessment Year's Results (n = 30 for Each Grade/Sex Subsample)

Grade	Seriation		Length Transitivity*		Weight Transitivity*	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Kindergarten						
Males	1.867	1.167	3.600	1.993	4.333	1.268
Females	2.000	.983	3.667	1.988	4.267	1.596
Total	1.933	1.071	3.633	1.974	4.300	1.430
Third						
Males	3.800	.887	4.133	1.889	4.667	1.268
Females	3.667	.661	4.433	1.356	4.933	.365
Total	3.733	.778	4.283	1.637	4.800	.935
Combined Grade						
Males	2.833	1.416	3.867	1.944	4.500	1.269
Females	2.833	1.181	4.050	1.731	4.600	1.196
Total	2.833	1.298	3.958	1.835	4.550	1.229

*See Brainerd (1973b) for norms for Canadian kindergarten and first and second graders.

TABLE 6

Means and Standard Deviations for the Some-All, Dichotomous Sorting, and Cardinality Tasks from the Initial Assessment Year's Results (n = 30 for Each Grade/Sex Subsample)

Grade	Some-All		Dichotomous Sorting		Cardinality*	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Kindergarten						
Males	3.433	.728	1.133	.819	1.900	1.269
Females	3.567	.817	1.067	.868	1.667	1.213
Total	3.500	.770	1.100	.838	1.783	1.237
Third						
Males	3.800	.484	2.100	.759	3.933	1.048
Females	3.867	.434	2.100	.803	3.600	1.070
Total	3.833	.457	2.100	.775	3.767	1.063
Combined Grade						
Males	3.617	.640	1.617	.922	2.917	1.544
Females	3.717	.666	1.583	.979	2.633	1.494
Total	3.667	.653	1.600	.947	2.775	1.520

*See Brainerd (1973a) for norms for Canadian kindergarten and first graders.

TABLE 7

Means and Standard Deviations for the Number Conservation, Length Conservation, and Weight Conservation Tasks from the Initial Assessment Year's Results (n = 30 for Each Grade/Sex Subsample)

Grade	Number Conservation*		Length Conservation				Weight Conservation			
			Identity		Equivalence**		Identity		Equivalence**	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Kindergarten										
Males	4.067	2.258	3.133	1.795	1.933	2.116	3.567	1.756	2.133	2.417
Females	4.267	2.348	3.933	1.701	2.633	2.312	3.633	1.991	2.467	2.300
Total	4.167	2.286	3.533	1.780	2.283	2.225	3.600	1.861	2.300	2.346
Third										
Males	6.733	.828	5.233	1.455	5.133	1.961	5.500	1.358	5.100	2.107
Females	6.600	1.037	4.833	1.724	4.033	2.723	4.333	2.057	4.000	2.716
Total	6.667	.933	5.033	1.594	4.583	2.417	4.917	1.825	4.550	2.473
Combined Grade										
Males	5.400	2.157	4.183	1.935	3.533	2.587	4.533	1.836	3.617	2.700
Females	5.433	2.150	4.383	1.757	3.333	2.602	3.983	2.038	3.233	2.613
Total	5.417	2.144	4.283	1.843	3.433	2.586	4.258	1.951	3.425	2.653

*See Brainerd and Brainerd (1972) for norms for Canadian kindergarten and first and second graders.

**See Brainerd (1973b) for norm for Canadian kindergarten and first and second graders.

TABLE 8

Hoyt Reliabilities for Various Groupement Subscales for Two Samples, Combining Kindergarten, Third Grade, and Sixth Grades (N = 180) for the U.S. Sample and Combining Kindergarten, and First, Second, and Third Grades (N = 255) for the Canadian Sample

Subscale	Hoyt		Standard Error of Measurement	
	U.S.	Canadian	U.S.	Canadian
All (64) Groupement Items	.88	(.91)	3.01	(2.77)
All (32) Class Groupement (I-IV) Items	.85	(.82)	2.21	(2.60)
All (32) Relational Groupement (V-VIII) Items	.84	(.83)	1.90	(1.93)
All (32) Composition Groupement Items	.81	(.86)	2.32	(2.15)
All (32) Inversion/Reciprocity Groupement Items	.84	(.81)	1.81	(1.63)
All (16) Class Composition Groupement Items	.85	(.83)	1.61	(1.69)
All (16) Class Inversion Groupement Items	.78	(.80)	1.29	(1.01)
All (16) Relational Composition Groupement Items	.71	(.77)	1.44	(1.52)
All (16) Relational Reciprocity Groupement Items	.75	(.75)	1.18	(1.47)
All (8) Groupement I Items	.62	(.65)	.91	(1.03)
All (8) Groupement II Items	.67	(.65)	.92	(.99)
All (8) Groupement III Items	.69	(.66)	1.13	(1.22)
All (8) Groupement IV Items	.76	(.72)	1.03	(1.06)
All (8) Groupement V Items	.67	(.70)	.81	(.98)
All (8) Groupement VI Items	.78	(.75)	.62	(.54)
All (8) Groupement VII Items	.75	(.74)	.93	(.88)
All (8) Groupement VIII Items	.65	(.68)	.99	(1.11)

TABLE 9

Hoyt Reliabilities for Various Conservation Subscales
Combining Kindergarten and Third Grades (N = 120) for the U.S. Sample
(Initial Assessment Year's Results)

Subscale	Hoyt	Standard Error of Measurement
All (7) Conservation of Number Items	.87	.72
All (24) Conservation of Length and Weight Items (Supporting Explanation Required)	.95	1.75
All (24) Conservation of Length and Weight Items (Supporting Explanation Not Required)	.94	1.72
All (12) Conservation of Length Items (Supporting Explanation Required)	.94	1.06
All (12) Conservation of Length Items (Supporting Explanation Not Required)	.94	1.03
All (12) Conservation of Weight Items (Supporting Explanation Required)	.93	1.13
All (12) Conservation of Weight Items (Supporting Explanation Not Required)	.93	1.09
All (12) Identity Conservation Items (Supporting Explanation Required)	.87	1.24
All (12) Identity Conservation Items (Supporting Explanation Not Required)	.85	1.17
All (12) Equivalence Conservation Items (Supporting Explanation Required)	.93	1.12
All (12) Equivalence Conservation Items (Supporting Explanation Not Required)	.93	1.14
All (12) Conservation Prediction Items (Supporting Explanation Required)	.88	1.26
All (12) Conservation Prediction Items (Supporting Explanation Not Required)	.87	1.23
All (12) Conservation Judgment Items (Supporting Explanation Required)	.91	1.17
All (12) Conservation Judgment Items (Supporting Explanation Not Required)	.91	1.15

TABLE 10

Hoyt Reliabilities for the Seriation, Transitivity of Length, and Transitivity of Weight Subscales Combining Kindergarten and Third Grades (N = 120) for the U.S. Sample (Initial Assessment Year's Results)

Subscale	Hoyt	Standard Error of Measurement
All (5) Seriation Items	.63	.71
All (5) Transitivity of Length Items	.94	.39
All (5) Transitivity of Weight Items	.91	.33
All (10) Transitivity of Length and Weight Items Combined	.87	.81

TABLE 11

Hoyt Reliabilities for the Some-All and Cardinality Tasks Combining Kindergarten and Third Grades (N = 120) for the U.S. Sample (Initial Assessment Year's Results)

Subscale	Hoyt	Standard Error of Measurement
All (4) Some-All Items	.37	.45
All (5) Cardinality Items	.72	.72

TABLE 12

Hoyt Reliabilities for Subscales of the Class Inclusion Task Combining Kindergarten and Third and Sixth Grades for the U.S. Sample (Initial Assessment Year's Results)

Subscale	Hoyt	Standard Error of Measurement
Class Inclusion Items 1 through 4	.63	.63
All (5) Class Inclusion Items	.67	.75

REFERENCES

Beilin, H. On the development of physical concepts. In T. Mischel (Ed.), Genetic psychology and epistemology, New York: Academic Press, 1971. Pp. 85-119.

Brainerd, C. J. Structures of thought in middle-childhood: Recent research on Piaget's concrete-operational groupements. Paper presented at the Third Annual Meeting on Structural Learning, Philadelphia, March 1972.

Brainerd, C. J. Mathematical and behavioral foundations of number. Journal of General Psychology, 1973, 88, 221-281. (a)

Brainerd, C. J. Order of transitivity, conservation, and class-inclusion of length and weight. Developmental Psychology, 1973, 8(1), 105-116. (b)

Brainerd, C. J., & Brainerd, S. H. Order of acquisition of number and quantity conservation. Child Development, 1972, 43, 1401-1406.

Brainerd, C. J., & Hooper, F. H. A methodological analysis of developmental studies of identity conservation and equivalence conservation. Psychological Bulletin, 1975, 82(5), 725-737.

Carver, R. P. Two dimensions of tests: Psychometric and edumetric. American Psychologist, 1974, 29(7), 512-518.

Coxford, A. F. The effects of instruction on stage placement in Piaget's seriation experiments. The Arithmetic Teacher, 1964, 1, 4-9.

Dihoff, R. E. Multidimensional scaling of Piagetian task performance. Technical Report No. 316. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1975.

Elkind, D. Discrimination, seriation, and numeration of size and dimensional differences in young children: Piaget replication study VI. The Journal of Genetic Psychology, 1964, 104, 275-296.

Elkind, D. Conservation and concept formation. In D. Elkind and J. H. Flavell (Eds.) Studies in cognitive development: Essays in honor of Jean Piaget. New York: Oxford, 1969, 171-190.

Flavell, J. H. The developmental psychology of Jean Piaget. Princeton, N. J.: Van Nostrand, 1963.

Flavell, J. H. Concept development. In P. H. Mussen (Ed.), Carmichael's manual of child psychology. Vol. 1. New York: Wiley, 1970, Pp. 983-1059.

Flavell, J. H. Stage-related properties of cognitive development. Cognitive Psychology, 1971, 2, 421-453.

Flavell, J. H. An analysis of cognitive-developmental sequences. Genetic Psychology Monographs, 1972, 86, 279-350.

Furth, H. G. Piaget and knowledge: Theoretical foundations. Englewood Cliffs, N. J.: Prentice-Hall, 1969.

Furth, H. G., Youniss, J., & Ross, B. M. Children's utilization of logical symbols. An interpretation of conceptual behavior based on Piagetian theory. Developmental Psychology, 1970, 3, 36-57.

Goodnow, J. A test of milieu differences with some of Piaget's tasks. Psychological Monographs, 1962, 76(36, Whole No. 555).

Gonchar, A. A study in the nature and development of the natural number concept. Technical Report No. 340. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1975.

Hooper, F. H. Piaget's conservation tasks: The logical and developmental priority of identity conservation. Journal of Experimental Child Psychology, 1969, 8, 234-249.

Hooper, F. H. Cognitive assessment across the life-span: Methodological implications of the organismic approach. In J. R. Nesselroade and H. W. Reese (Eds.), Life-span developmental psychology: Methodological issues. New York: Academic Press, 1973. Pp. 299-316.

Hooper, F. H., & Klausmeier, H. J. Description and rationale for a longitudinal assessment of children's cognitive development and concept learning. Working Paper No. 113. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1973.

Hooper, F. H., Swinton, S. S., & Sipple, T. S. An initial analysis of concrete operations task performances and memory variables for children aged five to twelve years. Technical Report No. 371. Madison: Wisconsin Research and Development Center for Cognitive Learning, in press.

Inhelder, B., & Piaget, J. The early growth of logic in the child: Classification and seriation. New York: Harper & Row, 1964.

Kamii, C., & Peper, R. A Piagetian method of evaluating preschool children's development in classification. Unpublished manuscript, Ypsilanti, Michigan, Public Schools, July 1969.

Klausmeier, H. J., Ghatala, E. S., & Frayer, D. A. Conceptual learning and development: A cognitive view. New York: Academic Press, 1974.

Klausmeier, H. J., & Hooper, F. H. Conceptual development and instruction. In F. Kerlinger and J. B. Carroll (Eds.), Review of research in education, Vol. II. Itasca, Ill.: Peacock, 1974. Pp. 3-54.

Kofsky, E. Developmental scalogram analysis of classificatory behavior. Unpublished doctoral dissertation, University of Rochester, 1963.

Kofsky, E. A scalogram study of classificatory development. Child Development, 1966, 37, 191-204.

Piaget, J. The psychology of intelligence. Totowa, New Jersey: Littlefield Adams, 1960.

Piaget, J. Piaget's theory. In P. H. Mussen (Ed.), Carmichael's manual of child psychology. Vol. 1. New York: Wiley, 1970. Pp. 703-732. (a)

Piaget, J. Structuralism. New York: Basic Books, 1970. (b)

Piaget, J. Essai de logique opératoire. Paris: Dunod, 1972.

Rothenberg, B. Conservation of number among four- and five-year-old children: Some methodological considerations. Child Development, 1969, 40(2), 383-406.

Swinton, S. S. Spatial ability, letter confusions, and beginning reading. Unpublished doctoral dissertation. University of Chicago, 1973.

Toniolo, T. A., & Hooper, F. H. Micro-analysis of logical reasoning relationships: Conservation and transitivity. Technical Report No. 326. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1975.

Weinreb, N., & Brainerd, C. J. A developmental study of Piaget's groupement model of the emergence of speed and time concepts. Child Development, 1975, 46, 476-485.

Wepman, J. M., & Morency, A. Auditory memory span test: Manual for administration, scoring and interpretation. Chicago: Language Research Associates, 1973. (a)

Wepman, J. M., & Morency, A. The auditory sequential memory test: Manual for administration, scoring and interpretation. Chicago: Language Research Associates, 1973. (b)

Wohlwill, J. F. Piaget's system as a source of empirical research. Merrill-Palmer Quarterly, 1963, 9, 253-262.

APPENDIX A

Complete Administration and Scoring Procedures
for the Concrete Operations Task Series

Groupement I

E reads the questions very slowly and emphasizes the words underlined. E may repeat questions only.

I. Circular Stimulus

A. Preliminary Counting

1. COUNT ALL THE CIRCLES THAT HAVE SOME YELLOW ON THEM. (4)*

2. COUNT ALL THE CIRCLES THAT DON'T HAVE YELLOW ON THEM. (4)*

B. Composition

1. ARE THERE THE SAME NUMBER OF CIRCLES WITH YELLOW ON THEM AS THERE ARE CIRCLES?

2. ARE THERE MORE CIRCLES THAN THERE ARE CIRCLES WITH YELLOW ON THEM?

C. Inversion

1. IF I TOOK AWAY THE CIRCLES WITH YELLOW ON THEM WOULD THERE BE SOME CIRCLES LEFT?

2. IF I TOOK AWAY THE CIRCLES WITH YELLOW ON THEM WOULD ALL THE CIRCLES BE GONE?

II. Triangular Stimulus

A. Preliminary Counting

1. COUNT ALL THE TRIANGLES THAT HAVE SOME YELLOW ON THEM. (4)*

2. COUNT ALL THE TRIANGLES THAT DON'T HAVE YELLOW ON THEM. (4)*

B. Composition

1. ARE THERE THE SAME NUMBER OF TRIANGLES WITH YELLOW ON THEM AS THERE ARE TRIANGLES?

2. ARE THERE MORE TRIANGLES THAN THERE ARE TRIANGLES WITH YELLOW ON THEM?

C. Inversion

1. IF I TOOK AWAY THE TRIANGLES WITH YELLOW ON THEM WOULD THERE BE SOME TRIANGLES LEFT?

2. IF I TOOK AWAY THE TRIANGLES WITH YELLOW ON THEM WOULD ALL THE TRIANGLES BE GONE?

* E may help S obtain correct number of each stimulus.

Groupement II

E reads the questions very slowly and emphasizes the words underlined. E may repeat questions only.

I. Circular Stimulus

A. Preliminary Counting

1. COUNT ALL THE CIRCLES THAT HAVE SOME RED ON THEM. (4)*

2. COUNT ALL THE CIRCLES THAT DON'T HAVE RED ON THEM. (4)*

B. Composition

1. ARE THERE THE SAME NUMBER OF CIRCLES WITH RED ON THEM AS THERE ARE CIRCLES?

2. ARE THERE MORE CIRCLES THAN THERE ARE CIRCLES WITH RED ON THEM?

C. Inversion

1. IF I TOOK AWAY THE CIRCLES WITH RED ON THEM, WOULD THERE BE SOME CIRCLES LEFT?

2. IF I TOOK AWAY THE CIRCLES WITH RED ON THEM, WOULD ALL THE CIRCLES BE GONE?

II. Triangular Stimulus

A. Preliminary Counting

1. COUNT ALL THE TRIANGLES THAT HAVE SOME RED ON THEM. (4)*

2. COUNT ALL THE TRIANGLES THAT DON'T HAVE RED ON THEM. (4)*

B. Composition

1. ARE THERE THE SAME NUMBER OF TRIANGLES WITH RED ON THEM AS THERE ARE TRIANGLES?

2. ARE THERE MORE TRIANGLES THAN THERE ARE TRIANGLES WITH RED ON THEM?

C. Inversion

1. IF I TOOK AWAY THE TRIANGLES WITH RED ON THEM, WOULD THERE BE SOME TRIANGLES LEFT?

2. IF I TOOK AWAY THE TRIANGLES WITH RED ON THEM, WOULD ALL THE TRIANGLES BE GONE?

* E may help S obtain correct number of each stimulus.

Groupement III

E reads the question very slowly and emphasizes the words underlined. E may repeat questions only.

I. Circular Stimulus

A. Preliminary Counting

1. COUNT ALL THE CIRCLES THAT HAVE SOME RED ON THEM. (4)*

2. COUNT ALL THE CIRCLES THAT HAVE SOME YELLOW ON THEM. (4)*

B. Composition

1. ARE THERE THE SAME NUMBER OF CIRCLES WITH RED ON THEM AS THERE ARE CIRCLES WITH BOTH RED AND YELLOW ON THEM?

2. ARE THERE MORE CIRCLES WITH RED ON THEM THAN THERE ARE CIRCLES WITH BOTH RED AND YELLOW ON THEM?

C. Inversion

1. IF I TOOK AWAY THE CIRCLES WITH RED ON THEM, WOULD THERE BE ANY CIRCLES WITH BOTH RED AND YELLOW ON THEM LEFT?

2. IF I TOOK AWAY THE CIRCLES WITH RED ON THEM, WOULD ALL THE CIRCLES WITH BOTH RED AND YELLOW ON THEM BE GONE?

II. Triangular Stimulus

A. Preliminary Counting

1. COUNT ALL THE TRIANGLES THAT HAVE SOME RED ON THEM. (4)*

2. COUNT ALL THE TRIANGLES THAT HAVE SOME YELLOW ON THEM. (4)*

B. Composition

1. ARE THERE THE SAME NUMBER OF TRIANGLES WITH YELLOW ON THEM AS THERE ARE TRIANGLES WITH BOTH RED AND YELLOW ON THEM?

2. ARE THERE MORE TRIANGLES WITH YELLOW ON THEM THAN THERE ARE TRIANGLES WITH BOTH RED AND YELLOW ON THEM?

C. Inversion

1. IF I TOOK AWAY THE TRIANGLES WITH YELLOW ON THEM WOULD THERE BE ANY TRIANGLES WITH BOTH RED AND YELLOW ON THEM LEFT?

2. IF I TOOK AWAY THE TRIANGLES WITH YELLOW ON THEM, WOULD ALL THE TRIANGLES WITH BOTH RED AND YELLOW BE GONE?

* E may help S obtain correct number of each stimulus.

Groupement IV

E reads questions very slowly and emphasizes words underlined. E may repeat questions only.

I. Stimulus 1

A. Preliminary Counting

1. COUNT ALL THE YELLOW THINGS. (4)*

2. COUNT ALL THE YELLOW CIRCLES. (2)*

B. Composition

1. ARE THERE THE SAME NUMBER OF YELLOW CIRCLES AS YELLOW THINGS?

2. ARE THERE MORE YELLOW THINGS THAN YELLOW CIRCLES?

C. Inversion

1. IF I TOOK AWAY THE YELLOW THINGS, WOULD THERE BY ANY YELLOW CIRCLES LEFT?

2. IF I TOOK AWAY THE YELLOW THINGS WOULD ALL THE YELLOW CIRCLES BE GONE?

II. Stimulus 2

A. Preliminary Counting

1. COUNT ALL THE YELLOW THINGS. (4)*

2. COUNT ALL THE TRIANGLES. (2)*

B. Composition

1. ARE THERE THE SAME NUMBER OF YELLOW TRIANGLES AS YELLOW THINGS?

2. ARE THERE MORE YELLOW THINGS THAN YELLOW TRIANGLES?

C. Inversion

1. IF I TOOK AWAY THE YELLOW THINGS, WOULD THERE BY ANY YELLOW TRIANGLES LEFT?

2. IF I TOOK AWAY THE YELLOW THINGS, WOULD ALL THE YELLOW TRIANGLES BE GONE?

* E may help S obtain correct number of each stimulus.

Groupement V

Like transitivity--the sticks are separated by 2 ft. The middle stick is brought to each side and compared.
E reads the question very slowly and emphasizes the words underlined.
E may repeat questions only.

I. Length

A. Preliminary Comparisons

1. E shows S that the Blue stick is shorter than the Green stick.*

2. E shows S that the Green stick is shorter than the Red stick.*

B. Composition

1. ARE THE BLUE AND RED STICKS THE SAME LENGTH?

2. IS THE BLUE STICK SHORTER THAN THE RED STICK?

C. Reciprocity Comparisons

1. E shows S that the Red stick is longer than the Green stick.*

2. E shows S that the Green stick is longer than the Blue stick.*

D. Reciprocity

1. ARE THE RED AND BLUE STICKS THE SAME LENGTH?

2. IS THE RED STICK LONGER THAN THE BLUE STICK?

II. Weight

A. Preliminary Comparisons

1. E shows S that the Red stick is lighter than the Green stick.*

2. E shows S that the Green stick is lighter than the Blue stick.*

B. Composition

1. DO THE RED AND BLUE STICKS WEIGH THE SAME?

2. IS THE RED STICK LIGHTER THAN THE BLUE STICK?

C. Reciprocity Comparisons.

1. E shows S that the Blue stick is heavier than the Green

Groupement V continued

stick.*

2. E shows S that the Green stick is heavier than the Red stick.*

D. Reciprocity

1. DO THE BLUE AND RED STICKS WEIGH THE SAME?

2. IS THE BLUE STICK HEAVIER THAN THE RED STICK?

* E first asks S what is the relationship between the two stimuli. E helps S to understand and verbalize the relationship before going on, i.e., ARE THESE THE SAME? HOW ARE THEY DIFFERENT? WHICH ONE IS LONGER (SHORTER, HEAVIER, LIGHTER)?

Groupement VI

E reads questions very slowly and emphasizes the words underlined. E may repeat questions only.

I. Length

A. Preliminary Comparisons

1. E shows S that the Blue and Green sticks are the same length.*

2. E shows S that the Green and Red sticks are the same length.*

B. Composition

1. ARE THE BLUE AND RED STICKS THE SAME LENGTH?

2. IS THE BLUE STICK SHORTER THAN THE RED STICK?

C. Reciprocity Comparisons

1. E shows S that the Red and Green sticks are the same length.*

2. E shows S that the Green and Blue sticks are the same length.*

D. Reciprocity

1. ARE THE RED AND BLUE STICKS THE SAME LENGTH?

2. IS THE RED STICK LONGER THAN THE BLUE STICK?

II. Weight

A. Preliminary Comparisons

1. E shows S that the Red and Green sticks weigh the same.*

2. E shows S that the Green and Blue sticks weigh the same.*

B. Composition

1. DO THE RED AND BLUE STICKS WEIGH THE SAME?

2. IS THE RED STICK LIGHTER THAN THE BLUE STICK?

C. Reciprocity Comparisons.

1. E shows S that the Blue and Green sticks weigh the same.*

2. E shows S that the Green and Red sticks weigh the same.*

Groupement VI continued

D. Reciprocity

1. DO THE BLUE AND RED STICKS WEIGH THE SAME?

2. IS THE BLUE STICK HEAVIER THAN THE RED STICK?

* E first asks S what is the relationship between the two stimuli. E helps S to understand and verbalize the relationship before going on, i.e., ARE THESE THE SAME? HOW ARE THEY DIFFERENT? WHICH ONE IS LONGER (SHORTER, HEAVIER, LIGHTER)?

Groupement VII

E reads questions very slowly and emphasizes the words underlined. E may repeat questions only.

Length and Weight

I. Preliminary Comparisons

A. E shows S that the Red stick is both shorter and lighter than the Blue stick.*

B. E shows S that the Blue stick is both shorter and lighter than the Green stick.*

II. Composition

A. ARE THE RED AND GREEN STICKS THE SAME LENGTH?

B. DO THE RED AND GREEN STICKS WEIGH THE SAME?

C. IS THE RED STICK SHORTER THAN THE GREEN STICK?

D. IS THE RED STICK LIGHTER THAN THE GREEN STICK?

III. Reciprocity Comparisons

A. E shows S that the Green stick is both longer and heavier than the Blue stick.*

B. E shows S that the Blue stick is both longer and heavier than the Red stick.*

IV. Reciprocity

A. ARE THE GREEN AND RED STICKS THE SAME LENGTH?

B. DO THE GREEN AND RED STICKS WEIGH THE SAME?

C. IS THE GREEN STICK LONGER THAN THE RED STICK?

D. IS THE GREEN STICK HEAVIER THAN THE RED STICK?

* E first asks S what is the relationship between the two stimuli. E helps S to understand and verbalize the relationship before going on, i.e., ARE THESE THE SAME? HOW ARE THEY DIFFERENT? WHICH ONE IS LONGER (SHORTER, HEAVIER, LIGHTER)?

Groupement VIII

E reads questions very slowly and emphasizes the words underlined. E may repeat questions only.

I. Preliminary Comparisons

A. E shows S that the Green stick is shorter and the same weight as the Red stick.*

B. E shows S that the Red stick is shorter and the same weight as the Blue stick.*

II. Composition

A. ARE THE GREEN AND BLUE STICKS THE SAME LENGTH?

B. DO THE GREEN AND BLUE STICKS WEIGH THE SAME?

C. IS THE GREEN STICK SHORTER THAN THE BLUE STICK?

D. IS THE GREEN STICK LIGHTER THAN THE BLUE STICK?

III. Reciprocity Comparisons

A. E shows S that the Blue stick is longer and weighs the same as the Red stick.*

B. E shows S that the Red stick is longer and weighs the same as the Green stick.*

IV. Reciprocity

A. ARE THE BLUE AND GREEN STICKS THE SAME LENGTH?

B. DO THE BLUE AND GREEN STICKS WEIGH THE SAME?

C. IS THE BLUE STICK LONGER THAN THE GREEN STICK?

D. IS THE BLUE STICK HEAVIER THAN THE GREEN STICK?

* E first asks S what is the relationship between the two stimuli. E helps S to understand and verbalize the relationship before going on, i.e., ARE THESE THE SAME? HOW ARE THEY DIFFERENT? WHICH ONE IS LONGER (SHORTER, HEAVIER, LIGHTER)?

Dichotomies

DIVIDE ALL THESE DRAWINGS INTO TWO BUNCHES. PUT ONE KIND HERE AND ONE KIND HERE. For 2nd and 3rd Dichotomies, E adds, BUT DO IT IN A DIFFERENT WAY THAN BEFORE.

1st Dichotomy

a. Exhaustive sort with number as only criterion
b. Exhaustive sort with shape as only criterion
c. Exhaustive sort with color as only criterion
d. Other

2nd Dichotomy

a. Exhaustive sort with number as only criterion
b. Exhaustive sort with shape as only criterion
c. Exhaustive sort with color as only criterion
d. Other

3rd Dichotomy

a. Exhaustive sort with number as only criterion
b. Exhaustive sort with shape as only criterion
c. Exhaustive sort with color as only criterion
d. Other

Some-All

1. LOOK AT ALL THE RED FIGURES. ARE ALL THE RED FIGURES TRIANGLES?

   Yes*, No, Other

2. LOOK AT ALL THE TRIANGLES. ARE ALL THE TRIANGLES RED?

   No*, Yes, Other

3. LOOK AT ALL THE CIRCLES. ARE ALL THE CIRCLES BLUE?

   Yes*, No, Other

4. LOOK AT ALL THE BLUE FIGURES. ARE ALL THE BLUE FIGURES CIRCLES?

   No*, Yes, Other

* correct response

Class Inclusion

1. Materials: 3 red and 2 blue triangles

   ARE THERE MORE TRIANGLES OR MORE RED FIGURES?

   more triangles*, more red figures, other

2. Materials: 3 yellow and 2 blue circles

   ARE THERE MORE BLUE FIGURES OR MORE CIRCLES?

   more circles*, more blue figures, other

3. Materials: 3 red and 2 blue triangles, 4 blue circles

   a. ARE THERE MORE TRIANGLES OR MORE RED FIGURES?

      more triangles*, more red figures, other

   b. ARE THERE MORE BLUE FIGURES OR MORE CIRCLES?

      more blue figures*, more circles, other

   c. ARE THERE MORE BLUE FIGURES OR MORE TRIANGLES?

      more blue figures*, more triangles, other

* correct response

GPO 810-000-0

Combinatorial Reasoning

SHOW ME ALL THE PAIRS OF CHIPS YOU CAN MAKE USING THESE COLORS. THE TWO RULES ARE THAT EACH PAIR MUST HAVE TWO COLORS AND EACH TIME YOU ARE TO PUT DOWN A NEW OR DIFFERENT PAIR OF COLORS.

A. Four Colors

Correct (6) Pairs: Red (Green, Yellow, Blue)
Green (Yellow, Blue)
Yellow (Blue)

Number of correct pairs:_____

Number of repeated pairs:_____

Approach (indicate one):
1. A(B,C,D) & B(C,D) & C(D)
2. A(B,C,D) & B(A,C,D) & C(A,B,D) & D(A,B,C)
3. Random, no apparent system
4. Begins one of the above, and shifts to another of the above
5. Other

B. Six Colors

Correct (15) Pairs: Red (Green, Yellow, Blue, White, Orange)
Green (Yellow, Blue, White, Orange)
Yellow (Blue, White, Orange)
Blue (White, Orange)
White (Orange)

Number of correct pairs:_____

Number of repeated pairs:_____

Approach: Same as above

C. Eight Colors*

Additional Correct (13) Pairs: Brown (Red, Green, Yellow, Blue, White, Orange, Light Blue)
Light Blue (Red, Green, Yellow, Blue, White, Orange)

Number of correct pairs:_____

Number of repeated pairs:_____

Approach: Same as above

*Administer only if 12 of the derived 15 possible correct pairs (i.e., correct pairs minus repeated pairs) were formed with six colors.

Cardinality I

NOW WE ARE GOING TO PLAY A GAME. I AM GOING TO SHOW YOU SOME CARDS WITH TWO ROWS OF DOTS ON THEM. I WANT YOU TO FIGURE OUT WHETHER THERE ARE THE SAME NUMBER OF RED DOTS AS GREEN DOTS, OR IF ONE OF THE TWO ROWS HAS MORE DOTS.

ONE SPECIAL RULE YOU MUST FOLLOW - YOU CANNOT COUNT THE DOTS - YOU HAVE TO FIGURE OUT THE ANSWER SOME OTHER WAY.

One at a time E presents a card on the table in front of S with the green dots closest to S. S may not touch the card. E asks the questions below for each card. Allow as much time as needed.

Cardinality A (Red = 8, Green = 6)

ARE THERE THE SAME NUMBER OF RED DOTS AS GREEN DOTS ON THIS CARD?

No* Yes

DOES ONE OF THE ROWS HAVE MORE DOTS?

Yes* No

If yes, WHICH ONE? Red* Green
If no,

HERE IS A NEW CARD.

Cardinality B (Red = 8, Green = 6)

ARE THERE THE SAME NUMBER OF RED DOTS AS GREEN DOTS ON THIS CARD?

No* Yes

DOES ONE OF THE ROWS HAVE FEWER DOTS?

Yes* No

If yes, WHICH ONE? Green* Red
If no,

HERE IS A NEW CARD.

Cardinality C (Red = 8, Green = 10)

ARE THERE THE SAME NUMBER OF RED DOTS AS GREEN DOTS ON THIS CARD?

No* Yes

DOES ONE OF THE ROWS HAVE MORE DOTS?

Yes* No

If yes, WHICH ONE? Green* Red
If no,

* correct response

Cardinality I continued

HERE IS A NEW CARD.

Cardinality D (Red = 8, Green = 10)

ARE THERE THE SAME NUMBER OF RED DOTS AS GREEN DOTS ON THIS CARD?

No * Yes

DOES ONE OF THE ROWS HAVE FEWER DOTS?

Yes* No

If yes, WHICH ONE? Red* Green
If no,

HERE IS A NEW CARD.

Cardinality E (Red = 8, Green = 8)

ARE THERE THE SAME NUMBER OF RED DOTS AS GREEN DOTS ON THIS CARD?

Yes* No

DOES ONE OF THE ROWS HAVE MORE DOTS?

No * Yes

HERE IS A NEW CARD.

Cardinality F (Red = 8, Green = 8)

ARE THERE THE SAME NUMBER OF RED DOTS AS GREEN DOTS ON THIS CARD?

Yes* No

DOES ONE OF THE ROWS HAVE FEWER DOTS?

No * Yes

To check against counting watch for lip movements, and rhythmic motor responses.

E's judgment of counting on the part of S.

No * Yes

E asks S, DID YOU FIND THAT YOU COULD ANSWER ALL THE QUESTIONS WITHOUT COUNTING THE DOTS?

Yes* No

DID YOU HAVE TO COUNT SOMETIMES?

No * Yes

* correct reponse

Cardinality I continued

CAN YOU EXPLAIN HOW YOU WERE ABLE TO ANSWER THE QUESTIONS?

matched circle (correspondence)
doesn't know
irrelevant justification
counted circles
some were bunched together and
others were spread apart

Cardinality II

Story A — SUPPOSE THAT I HAD 8 COOKIES AND YOU HAD 6 COOKIES.

WOULD WE BOTH HAVE THE SAME NUMBER OF COOKIES?

No* Yes

WOULD ONE OF US HAVE MORE COOKIES?

Yes* No

If yes, WHICH ONE? E * S

If no,

Story B — SUPPOSE THAT I HAD 4 COOKIES AND YOU HAD 4 COOKIES.

WOULD WE BOTH HAVE THE SAME NUMBER OF COOKIES?

Yes* No

WOULD ONE OF US HAVE FEWER COOKIES?

No* Yes

E presents Card A_1 and asks:

HOW MANY DOTS ARE ON THIS CARD?

8* Other

If other, E helps S count the dots.

E places A & B between S and Card A_1 and asks:

HOW MANY DOTS ARE ON THIS CARD?

8* Other

If other, E helps S count the dots.

ARE THERE THE SAME NUMBER OF DOTS ON THESE CARDS?

Yes* No

DOES ONE OF THE CARDS HAVE FEWER DOTS?

No* Yes

E presents Card B_1 and asks:

HOW MANY DOTS ARE ON THIS CARD?

6* Other

If other, E helps S count the dots.

* correct response

Cardinality II continued

E places Card A & B between S and Card B_1 and asks:

HOW MANY DOTS ARE ON THIS CARD?

8* Other

If other, E helps S count the dots.

ARE THERE THE SAME NUMBER OF DOTS ON THESE CARDS?

No* Yes

**DOES ONE OF THE CARDS HAVE MORE DOTS?

Yes* No

**If yes, WHICH ONE? Green* Red

If no,

**E does not score these questions until both are asked.

*correct response

SERIATION

A-Serial Ordering

E presents sticks (1,3,4,6,7,8,10) in a scrambled fashion and not in a straight line.

HERE WE HAVE SOME STICKS. I WANT YOU TO ARRANGE THESE STICKS IN ORDER. REMEMBER ALL THE STICKS HAVE TO BE IN ORDER.

If the child hesitates E asks;

FIND THE SHORTEST STICK AND PLACE IT HERE (to the S's right) pause AND FIND THE LONGEST STICK AND PLACE IT HERE (to the S's left). NOW PLACE ALL THE OTHER STICKS IN ORDER BETWEEN THE LONGEST AND THE SHORTEST.

E helps S to finish the task if necessary.

ARE YOU FINISHED? ARE THEY JUST RIGHT?

E arranges sticks in correct order before proceeding to next task.

SERIATION

B-Additive Seriation

E adjusts the array so that there is an inch space between the sticks and a two inch space between the sticks where a stick is to be added. Pause.

E places the remaining sticks (2,5,9) an inch apart between the original array and the S in order and in the same ascending direction as the original array.

HERE ARE THREE MORE STICKS THAT GO WITH THE OTHER STICKS. CAN YOU SHOW ME WITHOUT TOUCHING THE STICKS WHERE THIS STICK (pointing to 2) WOULD GO INTO THE ORDER OF STICKS? E repeats this procedure with stick 5, then 9.

Prediction:

NOW PUT THESE STICKS INTO THE ORDER WITH THE OTHER STICKS. PUT THEM IN WHERE THEY BELONG.

If S fails to understand the task, E places one of the sticks for him.

After S has finished E asks;

HAVE YOU PLACED THE STICKS THE WAY YOU WANT THEM? CHECK AND MAKE SURE.

Placement: (If E helps, score that stick incorrect.)

GPO 810-980-7

SERIATION

Serial Correspondence

E places the circles between the S and the order array of sticks in a mixed fashion.

HERE ARE SOME CIRCLES, I WANT YOU TO ARRANGE THESE CIRCLES IN ORDER. REMEMBER ALL OF THE CIRCLES HAVE TO BE IN ORDER. PUT THEM IN THE SAME WAY AS THE STICKS.

If the child hesitates E asks;

C-Matching Case

FIND THE SMALLEST CIRCLE AND PLACE IT HERE (to the side of the shortest stick) pause AND FIND THE LARGEST CIRCLE AND PLACE IT HERE (to the side of the largest stick). NOW PLACE ALL THE OTHER CIRCLES IN ORDER BETWEEN THE LARGEST AND THE SMALLEST CIRCLE.

The circles should be very close together but not touching.

NOW LET'S MATCH EACH STICK TO THE CIRCLE IT GOES WITH. Pause to see if S can make the correct correspondence order.

If he hesitates E asks:

PUT THE LONGEST STICK WITH THE LARGEST CIRCLE. Pause. PUT THE SHORTEST STICK WITH THE SMALLEST CIRCLE. NOW PUT EACH OF THESE STICKS WITH THE CIRCLE THAT IT GOES WITH. THEY MUST BE THE RIGHT SIZE FOR EACH OTHER.

If S responds incorrectly E replaces the sticks and circles to correspondence and explains;

EACH STICK GOES WITH A CIRCLE. THEY ARE THE RIGHT SIZE FOR EACH OTHER.

E extends the stick array so there is an extra two sticks at each end of the circle array. Place sticks so the longest sticks are roughly 4 inches above the largest circles. Order sticks over spaces between circles. E points to stick 5 and asks:

D-Extension and Compression Cases

POINT TO THE CIRCLE THAT GOES WITH THIS STICK. THEY HAVE TO BE THE RIGHT SIZE FOR EACH OTHER.

E repeats this procedure for sticks 2 and 7.

Serial Correspondence continued

S may not move the sticks or circles.

E returns the sticks and circles to correspondence and once again establishes the relationship between the circles and sticks.

E compresses sticks (4 inches above largest circle) so all the sticks are one inch apart and clustered between circles 4 and 8. E points to stick 6.

POINT TO THE CIRCLE THAT GOES WITH THIS STICK. THEY HAVE TO BE THE RIGHT SIZE FOR EACH OTHER.

E repeats this procedure for stick 8, then 3.

E returns the sticks and circles to correspondence and once again establishes the relationship between the circles and sticks.

E scrambles the sticks. E points to stick 4 and asks:

E-Scrambled Case

WHAT CIRCLE GOES WITH THIS STICK? YOU CAN DO ANYTHING YOU WANT WITH THE STICKS. (Don't tell to construct the order even though it is permissible.) REMEMBER, THEY HAVE TO BE THE RIGHT SIZE FOR EACH OTHER.

E repeats this procedure for stick 9, then 5. If S moves the sticks during a trial, E scrambles the sticks again.

If S does not reconstruct - then E asks:

HOW CAN YOU BE SURE THAT THIS STICK (5) GOES WITH THIS CIRCLE (5)? YOU CAN DO ANYTHING YOU WANT WITH THE STICKS.

reconstructs
doesn't know or guessed
irrelevant justification
relevant justification but does not reconstruct

Conservation and Transitivity

Warm-Up

Materials:

Picture of two unequal parallel lines
Two blocks of unequal weight

Instructions:

(1) Length: The E places a picture of two perceptibly unequal parallel lines (10-cm and 20-cm) to the center of the table, approximately 8-10 inches from the S. The picture is arranged such that the longest (20-cm) line is nearest the S. The E then asks the following questions:

(a) ARE THESE TWO LINES THE SAME LENGTH?

Yes ____ No ____ I Don't Know ____ No Response ____

(b) WHICH LINE IS LONGER?

10-cm ____ 20-cm ____ I Don't Know ____ No Response ____

(c) WHICH LINE IS SHORTER?

10-cm ____ 20-cm ____ I Don't Know ____ No Response ____

Warm-Up continued

(2) Weight: The E gives the S a block to hold in each hand, and asks the following questions:

(a) ARE THESE TWO BLOCKS THE SAME WEIGHT?

Yes ___ No ___ I Don't Know ___ No Response ___

(b) WHICH BLOCK WEIGHS MORE?

Small ___ Large ___ I Don't Know ___ No Response ___

(c) WHICH BLOCK WEIGHS LESS?

Small ___ Large ___ I Don't Know ___ No Response ___

Note: If a S does not seem to understand the relational terms, the E may repeat the warm-up or that portion about which the S seems uncertain.

Transitivity of Length

Materials:

27-cm blue stick
28-cm blue stick
28-cm white stick

Instructions:

The E places the board, having a 27-cm blue stick and 28-cm blue stick glued down approximately one arm's length apart, 8-10 inches from the S in the middle of the table. The sticks are positioned such that the midpoint of each stick is in direct relation to the other stick. Taking the 28-cm white stick and placing it in the middle of the board between the two blue sticks, the E says:

HERE ARE SOME STICKS WE WILL BE WORKING WITH.

The E then places the 28-cm white stick next to the 28-cm blue stick, making the ends nearest the S even with one another, and so the S can observe the sticks to be of equal length. The S is required to verbalize this latter fact.

ARE THESE TWO STICKS THE SAME LENGTH?

Yes ___ No ___ I Don't Know ___ No Response ___

Next, the E places the 28-cm white stick next to the 27-cm blue stick, again making the ends nearest the S even with one another, and so the S can observe that the white stick is the longer of the two. The S is required to verbalize this latter fact.

IS ONE OF THE STICKS LONGER?

Yes ___ No ___ I Don't Know ___ No Response ___

(If "Yes," then) WHICH ONE?

White ___ Blue ___ I Don't Know ___ No Response ___

Transitivity of Length continued

Finally, the E removes the white stick from the table, and asks the following questions:

(a) ARE THESE TWO STICKS THE SAME LENGTH?

Yes ___ No ___ I Don't Know ___ No Response ___

(b) IS ONE OF THE STICKS LONGER?

Yes ___ No ___ I Don't Know ___ No Response ___

(If "Yes," then) WHICH ONE?

28-cm ___ 27-cm ___ I Don't Know ___ No Response ___

(c) IS ONE OF THE STICKS SHORTER?

Yes ___ No ___ I Don't Know ___ No Response ___

(If "Yes," then) WHICH ONE?

27-cm ___ 28-cm ___ I Don't Know ___ No Response ___

Transitivity of Weight

Materials:

One red and one gray clay ball of equal weight
One gray clay ball of a lighter weight

Instructions:

The E places the three clay balls in the middle of the table 8-10 inches from the S, and says:

HERE ARE SOME CLAY BALLS WE WILL BE WORKING WITH.

The E then hands the S one red and one gray clay ball of equal weight. The S is required to verbalize this latter fact.

DO THESE TWO CLAY BALLS WEIGH THE SAME?

Yes ___ No ___ I Don't Know ___ No Response ___

Next, the E removes the gray clay ball from the S's hand and places the gray ball on the table 8-10 inches in front of the hand in which it was held. Then the red clay ball is removed and placed in the hand opposite the one in which it originally appeared. Next the lighter gray clay ball is placed in the remaining empty hand, so the S will know that the red ball is the heavier of the two. The S also is required to verbalize this latter fact.

DOES ONE OF THE CLAY BALLS WEIGH MORE?

Yes ___ No ___ I Don't Know ___ No Response ___

(If "Yes," then) WHICH ONE?

Red ___ Gray ___ I Don't Know ___ No Response ___

Transitivity of Weight continued

The gray clay ball is removed and placed on the table 8-10 inches in front of the hand in which it was held. Finally, the E removes the red clay ball from the table, and asks the following questions:

(a) DO THESE TWO CLAY BALLS WEIGH THE SAME?

Yes ___ No ___ I Don't Know ___ No Response ___

(b) DOES ONE OF THE CLAY BALLS WEIGH MORE?

Yes ___ No ___ I Don't Know ___ No Response ___

(If "Yes," then) WHICH ONE?

Heavy ___ Light ___

(c) DOES ONE OF THE CLAY BALLS WEIGH LESS?

Yes ___ No ___ I Don't Know ___ No Response ___

(If "Yes," then) WHICH ONE?

Light ___ Heavy ___

GPO 810-880-6

Conservation of Length

Identity Format

Materials:

One 28-cm string

Instructions:

(1) Prediction: Placing the 28-cm string in the middle of the table 8-10 inches from the S, so the length runs horizontally in a straight line from the S's left to right, the E asks the following questions:

(a) IF I WERE TO MAKE THIS STRING INTO A CIRCLE, WOULD THE STRING STILL HAVE THE SAME LENGTH?

Yes ___ No ___ I Don't Know ___ No Response ___

(b) IF I WERE TO MAKE THIS STRING INTO A CIRCLE, WOULD THE STRING BE LONGER?

Yes ___ No ___ I Don't Know ___ No Response ___

(c) IF I WERE TO MAKE THIS STRING INTO A CIRCLE, WOULD THE STRING BE SHORTER?

Yes ___ No ___ I Don't Know ___ No Response ___

Conservation of Length continued

(2) Deformation: The E then forms the string into a circle (toward the S), and asks the following questions:

(a) IS THIS STRING THE SAME LENGTH AS BEFORE?

Yes ___ No ___ I Don't Know ___ No Response ___

(b) IS THIS STRING LONGER THAN BEFORE?

Yes ___ No ___ I Don't Know ___ No Response ___

(c) IS THIS STRING SHORTER THAN BEFORE?

Yes ___ No ___ I Don't Know ___ No Response ___

Conservation of Length

Equivalence Format

Materials:

Two 28-cm strings

Instructions:

The E places the two strings side-by-side in the middle of the table 8-10 inches from the S, so the length runs horizontally from the S's left to right, and so the strings are observed to be of equal length. The S is required to verbalize this latter fact.

ARE THESE TWO STRINGS THE SAME LENGTH?

Yes ___ No ___ I Don't Know ___ No Response ___

(1) Prediction: Leaving the strings exactly as they are while pointing to the string nearest the S, the E asks the following questions:

(a) IF I WERE TO MAKE THIS STRING INTO A CIRCLE, WOULD THE TWO STRINGS STILL HAVE THE SAME LENGTH?

Yes ___ No ___ I Don't Know ___ No Response ___

(b) IF I WERE TO MAKE THIS STRING INTO A CIRCLE, WOULD ONE OF THE STRINGS BE LONGER?

Yes ___ No ___ I Don't Know ___ No Response ___

(c) IF I WERE TO MAKE THIS STRING INTO A CIRCLE, WOULD ONE OF THE STRINGS BE SHORTER?

Yes ___ No ___ I Don't Know ___ No Response ___

Conservation of Length continued

(2) Deformation: The E then forms the string nearest the S into a circle (toward the S), and asks the following questions:

(a) ARE THESE TWO STRINGS THE SAME LENGTH AS BEFORE?

Yes ___ No ___ I Don't Know ___ No Response ___

(b) IS ONE OF THE STRINGS LONGER THAN BEFORE?

Yes ___ No ___ I Don't Know ___ No Response ___

(c) IS ONE OF THE STRINGS SHORTER THAN BEFORE?

Yes ___ No ___ I Don't Know ___ No Response ___

Conservation of Weight

Identity Format

Materials:

One green clay ball

Instructions:

(1) Prediction: Placing the green clay ball in the middle of the table 8-10 inches from the S, the E asks the following questions:

(a) IF I WERE TO ROLL THIS CLAY BALL INTO A HOT DOG, WOULD THE PIECE OF CLAY STILL HAVE THE SAME WEIGHT?

Yes ___ No ___ I Don't Know ___ No Response ___

(b) IF I WERE TO ROLL THIS CLAY BALL INTO A HOT DOG, WOULD THE PIECE OF CLAY WEIGH MORE?

Yes ___ No ___ I Don't Know ___ No Response ___

(c) IF I WERE TO ROLL THIS CLAY BALL INTO A HOT DOG, WOULD THE PIECE OF CLAY WEIGH LESS?

Yes ___ No ___ I Don't Know ___ No Response ___

Conservation of Weight continued

(2) Deformation: The E then rolls the clay ball into a hot dog, and asks the following questions:

(a) DOES THIS PIECE OF CLAY WEIGH THE SAME AS BEFORE?

Yes ___ No ___ I Don't Know ___ No Response ___

(b) DOES THIS PIECE OF CLAY WEIGH MORE THAN BEFORE?

Yes ___ No ___ I Don't Know ___ No Response ___

(c) DOES THIS PIECE OF CLAY WEIGH LESS THAN BEFORE?

Yes ___ No ___ I Don't Know ___ No Response ___

Conservation of Weight

Equivalence Format

Materials:

Two brown clay balls of equal weight

Instructions:

The E gives the S a clay ball to hold in each hand so the balls are observed to be of equal weight. The S is required to verbalize this latter fact.

ARE THESE TWO BALLS THE SAME WEIGHT?

Yes ___ No ___ I Don't Know ___ No Response ___

(1) Prediction: Taking the balls from the S and placing them on the table side-by-side 8-10 inches from the S, the E asks the following questions while pointing to one of the stimuli:

(a) IF I WERE TO FLATTEN THIS CLAY BALL INTO A PANCAKE, WOULD THE TWO PIECES OF CLAY STILL HAVE THE SAME WEIGHT?

Yes ___ No ___ I Don't Know ___ No Response ___

(b) IF I WERE TO FLATTEN THIS CLAY BALL INTO A PANCAKE, WOULD ONE OF THE PIECES OF CLAY WEIGH MORE?

Yes ___ No ___ I Don't Know ___ No Response ___

(c) IF I WERE TO FLATTEN THIS CLAY BALL INTO A PANCAKE, WOULD ONE OF THE PIECES OF CLAY WEIGH LESS?

Yes ___ No ___ I Don't Know ___ No Response ___

Conservation of Weight continued

(2) Deformation: The E then flattens the clay ball into a pancake, and asks the following questions:

(a) DO THESE TWO PIECES OF CLAY WEIGH THE SAME AS BEFORE?

Yes ___ No ___ I Don't Know ___ No Response ___

(b) DOES ONE OF THE PIECES OF CLAY WEIGH MORE THAN BEFORE?

Yes ___ No ___ I Don't Know ___ No Response ___

(c) DOES ONE OF THE PIECES OF CLAY WEIGH LESS THAN BEFORE?

Yes ___ No ___ I Don't Know ___ No Response ___

GPO 810-980-5

Conservation of Number

Materials:

20 plastic chips

Procedure: The experimenter and subject construct two parallel rows of evenly spaced chips in the center of the table. There is a precise perceptual correspondence between the elements of the two rows.

(1) Prediction: Leaving the rows exactly as they are, the experimenter asks the following questions:

(a) IF I WERE TO PUSH THE CHIPS IN THIS ROW (pointing to the row nearest the experimenter) VERY CLOSE TOGETHER, WOULD THE TWO ROWS STILL HAVE THE SAME NUMBER OF CHIPS?

HOW DO YOU KNOW?

(b) IF I WERE TO PUSH THE CHIPS IN THIS ROW (indicating the same row) VERY CLOSE TOGETHER, WOULD ONE OF THE ROWS HAVE MORE CHIPS?

(c) IF I WERE TO PUSH THE CHIPS IN THIS ROW (indicating the same row) VERY CLOSE TOGETHER, WOULD ONE OF THE ROWS HAVE FEWER CHIPS?

(2) Deformation: The experimenter pushes the chips in the nearest row together until they touch. The row nearest the subject is now roughly three times as long as the other row. The experimenter asks the following (randomly ordered) questions:

(a) DO THESE TWO ROWS HAVE THE SAME NUMBER OF CHIPS?

(b) DOES ONE OF THE ROWS HAVE MORE CHIPS NOW?

(c) DOES ONE OF THE ROWS HAVE FEWER CHIPS NOW? HOW DO YOU KNOW?

(3) E replaces rows to original order and then removes one chip (2nd from either end) from the row nearest E.

(a) DO THESE ROWS HAVE THE SAME NUMBER OF CHIPS?

(b) HOW DO YOU KNOW?

Auditory Sequencing Test

Administration with the child seated so his back is facing E, start by saying to the child:

I'M GOING TO SAY SOME NUMBERS TO YOU. LISTEN VERY CAREFULLY, AND WHEN I'M THROUGH SAY THEM RIGHT AFTER ME EXACTLY AS I SAID THEM.

Start with the first two digits, 6....9. Give both parts of Level 2. If the child succeeds on either sequence of Level 2 proceed through the test on this basis--discontinuing when a child fails both sequences of a level. The digits should be read at the rate of one per half second, and the voice would be dropped slightly on the last digit of a series.

Scoring

Level 2

6-9
8-3

Level 3

4-7-2
5-9-1

Level 4

8-5-3-1
3-9-8-6

Level 5

4-3-1-9-5
8-1-6-9-2

Level 6

5-2-7-4-9-6
9-2-1-7-3-5

Level 7

4-6-2-1-8-9-3
8-6-1-2-9-7-5

Level 8

4-7-1-8-5-3-9-2
2-1-7-5-8-4-9-3

Auditory Memory Span

Administration with the child seated so his back is facing E:

I'M GOING TO READ SOME WORDS TO YOU. ALL I WANT YOU TO DO IS REPEAT THE WORDS I READ WHEN I'M ALL THROUGH. LET'S TRY ONE OR TWO FOR PRACTICE. . .
CAR . . . BIRD . . . NOW, YOU SAY THOSE WORDS. . .

Wait for the answer. If he does repeat the two words in any order go to Level 2 and begin the test. If he does not repeat the words, have him try a second series. . .

LOOK . . . SEE . . . NOW, YOU SAY THOSE WORDS.

Continue illustrations until the task is understood. Then begin testing with the words listed under Level 2. Give all three parts of Level 2 and proceed to Level 3 without comment. If the child succeeds on any sequence of Level 2, proceed through the test on this basis . . . discontinuing when a child fails all three sequences on any level.

Speak each word sequence with a one-half second pause between each word. Do not group the word sequences as you read them, but drop your voice on the last word of each series. Accept any pronunciation of a word that is intelligible---do not insist upon nor correct pronunciation.

Auditory Memory Span

Level 2

BELT HOUSE

SCHOOL GHOST

BOOK STAIR

Level 3

NOISE MEN BED

HAIR WIFE ROOM

HEAD THING KNIFE

Level 4

CHAIR END CAVE STUFF

GUY CROSS FISH WAY

TOP LADY WALL BOAT

Level 5

TABLE DUCK WOOD BOY CLOUD

ROPE GRASS NIGHT HAND SHIP

BUSH HOME MEN BARN KIND

Level 6

TREE DAY ROCK FEET TIME SIDE

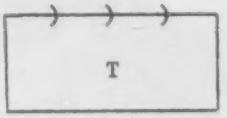
PEOPLE SHIRT LIGHT PLACE SNOW DOOR

FIRE GIRL LOT SUN PLACE LION

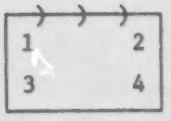
Visual Orientation Memory Test (Primary)

This test consists of 2 sample items and 20 test items. Sample items are not included in the score. Each of the items consists of two pages:

The first shows the "target" figure, centered on the page.



The second has 4 answer choices, arranged as illustrated.



One of the answer choices is identical to the target figure. The other three are all mirror-images of the target--left to right, upside-down, and left-right and upside-down. The child's task is to identify the answer exactly the same as the target he saw on the previous page. The position of the child's responses (numbered as shown) is checked on a separate score sheet. Each child is tested individually.

Administration

1. Sample items.
   Tell the child:

   I WILL SHOW YOU A PAGE WITH A PICTURE. LOOK AT IT CAREFULLY SO YOU WILL REMEMBER IT. LET'S TRY ONE.

   Open book to S1 target page.

   LOOK AT THIS PICTURE.

   Allow the child to look for 5 seconds. Turn to S1 answer page.

   CAN YOU POINT TO THE PICTURE THAT IS ON THE PAGE JUST LIKE THE ONE YOU SAW BY ITSELF?

If correct, (3):

GOOD. THEY WERE ALL THE SAME SHAPE, BUT THAT ONE WAS ON THE PAGE THE SAME WAY AS THE ONE YOU REMEMBERED.

Turn back to the target page of S1 so that the child can check to see that his answer was correct.

Say:
LET'S TRY ANOTHER ONE. LOOK AT THIS PICTURE.

Turn to S2 target page. Allow child to look for 5 seconds. Turn to S2 answer page.

POINT TO THE PICTURE JUST LIKE THE ONE YOU JUST SAW.

If correct, (1):

GOOD, THAT ONE WAS JUST LIKE THE ONE YOU REMEMBERED.

Turn back to the target page so that the child can check to see that his answer was correct.

Visual Orientation Memory Test continued

If incorrect on either sample, turn back to show target figure, say:

LOOK AT THE PICTURE AGAIN.

Turn page to show responses.

THE ONE YOU PICKED WASN'T ON THE PAGE THE SAME WAY AS THE ONE YOU WERE TO REMEMBER. POINT TO THE ONE THAT IS SITTING JUST THE SAME WAY.

If the child does not point to correct answer by the third trial of S2, discontinue testing.

2. Test Items

Say:

LET'S BEGIN. THIS TIME WE CAN'T TURN BACK TO LOOK AT THE PICTURE AGAIN, SO LOOK AT IT CAREFULLY.

Proceed through test, allowing up to 5 seconds to look at target, no limit on time to point to answer. Mark each response with a check (✓) on answer sheet. On items 5, 10, and 15 after child has responded, say:

REMEMBER TO LOOK AT ALL FOUR BEFORE YOU POINT.

If the child does not respond to an item, say:

MAKE A GUESS.

Remember, you should not tell the child that his error was because his selection went to the left or right or up or down---avoid all such labelling of directions to keep the test a visual non-verbal task.

NOTE: The words used in the instructions are just an example. You may change them to suit yourself. The important thing is that the child understands the task.

A child is expected to make some errors on the test items, so do not help or correct him on the test except as indicated above. Once you start the test items, give all 20 of them. A child may do some of the last ones correctly even though he missed many of the early ones. On the test items it is all right for the child to go a little faster if he wants to.

3. Scoring

For each item one of the answer boxes on the score sheet is starred (*). That is the correct response. To score the test, count the number of checks in the starred boxes. (The Samples 1 and 2 are not counted.) Write the number correct in the space provided at the bottom of the page.

APPENDIX B

Inter-item Analyses (Point Bi-Serial Correlation Coefficients)
for the Groupements Tasks

TABLE B-1

Point Bi-Serial Correlation Coefficients for All Groupement Items
Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)
(Initial Assessment Year's Results)

Scale	Item	Point Bi-Serial (correlation of item and total scale score)	Subscale	Item	Point Bi-Serial (correlation of item and total scale score)
All (64) Groupement Items	1	.50	All (64) Groupement Items (continued)	33	.30
	2	.26		34	.33
	3	.25		35	.41
	4	.37		36	.39
	5	.50		37	.25
	6	.27		38	.19
	7	.29		39	.24
	8	.34		40	.23
	9	.41		41	.26
	10	.26		42	.37
	11	.24		43	.24
	12	.32		44	.38
	13	.44		45	.14
	14	.26		46	.48
	15	.23		47	.20
	16	.40		48	.35
	17	.38		49	.41
	18	.10		50	.35
	19	.39		51	.31
	20	.35		52	.20
	21	.43		53	.33
	22	.21		54	.42
	23	.35		55	.33
	24	.39		56	.31
	25	.42		57	.46
	26	.35		58	.25
	27	.48		59	.15
	28	.46		60	.48
	29	.53		61	.48
	30	.42		62	.23
	31	.43		63	.38
	32	.40		64	.38

TABLE B-2

Point Bi-Serial Correlation Coefficients for All Class Groupement (I-IV) Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (32) Class Groupement (I-IV) Items	1	.59
	2	.41
	3	.14
	4	.24
	5	.67
	6	.39
	7	.23
	8	.31
	9	.61
	10	.47
	11	.25
	12	.27
	13	.55
	14	.45
	15	.21
	16	.33
	17	.47
	18	.23
	19	.44
	20	.37
	21	.51
	22	.28
	23	.44
	24	.42
	25	.49
	26	.46
	27	.48
	28	.42
	29	.59
	30	.53
	31	.36
	32	.33

TABLE B-3

Point Bi-Serial Correlation Coefficients for All Relational Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (32) Relational Groupement Items	1	.40
	2	.37
	3	.55
	4	.45
	5	.29
	6	.24
	7	.31
	8	.26
	9	.40
	10	.55
	11	.30
	12	.50
	13	.21
	14	.53
	15	.27
	16	.42
	17	.55
	18	.50
	19	.45
	20	.32
	21	.49
	22	.51
	23	.42
	24	.40
	25	.54
	26	.23
	27	.28
	28	.57
	29	.56
	30	.31
	31	.43
	32	.48

TABLE B-4

Point Bi-Serial Correlation Coefficients for All Composition Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (32) Composition Groupement Items	1	.57
	2	.40
	3	.61
	4	.41
	5	.56
	6	.44
	7	.55
	8	.45
	9	.45
	10	.24
	11	.46
	12	.31
	13	.50
	14	.47
	15	.61
	16	.53
	17	.29
	18	.34
	19	.25
	20	.18
	21	.18
	22	.21
	23	.13
	24	.30
	25	.34
	26	.30
	27	.29
	28	.17
	29	.42
	30	.19
	31	.19
	32	.40

TABLE B-5

Point Bi-Serial Correlation Coefficients for All Inversion/Reciprocity Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (32) Inversion/Reciprocity Groupement Items	1	.30
	2	.49
	3	.38
	4	.46
	5	.27
	6	.42
	7	.31
	8	.51
	9	.46
	10	.43
	11	.40
	12	.43
	13	.53
	14	.54
	15	.52
	16	.51
	17	.47
	18	.42
	19	.31
	20	.28
	21	.30
	22	.52
	23	.29
	24	.43
	25	.37
	26	.42
	27	.35
	28	.38
	29	.49
	30	.31
	31	.40
	32	.48

TABLE B-6

Point Bi-Serial Correlation Coefficients for All Class Composition Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (16) Class Composition Groupement Items	1	.63
	2	.54
	3	.69
	4	.52
	5	.69
	6	.60
	7	.63
	8	.58
	9	.49
	10	.36
	11	.50
	12	.37
	13	.52
	14	.52
	15	.60
	16	.59

TABLE B-7

Point Bi-Serial Correlation Coefficients for All Class Inversion Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180)
(Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (16) Class Inversion Groupement Items	1	.29
	2	.49
	3	.42
	4	.50
	5	.37
	6	.45
	7	.36
	8	.53
	9	.57
	10	.51
	11	.55
	12	.50
	13	.58
	14	.57
	15	.53
	16	.54

TABLE B-8

Point Bi-Serial Correlation Coefficients for All Relational Composition Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (16) Relational Composition Groupement Items	1	.42
	2	-
	3	.33
	4	.26
	5	.44
	6	.52
	7	.24
	8	.52
	9	.57
	10	.54
	11	.49
	12	.39
	13	.55
	14	.27
	15	.33
	16	.60

TABLE B-9

Point Bi-Serial Correlation Coefficients for All Relational Reciprocity Groupement Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (16) Relational Reciprocity Groupement Items	1	.62
	2	.50
	3	.34
	4	.30
	5	.33
	6	.52
	7	.31
	8	.40
	9	.55
	10	.54
	11	.47
	12	.47
	13	.57
	14	.34
	15	.48
	16	.52

GPO 810-980-3

TABLE B-10

Point Bi-Serial Correlation Coefficients for All Groupement I Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (8) Groupement I Items	1	.74
	2	.51
	3	.30
	4	.43
	5	.79
	6	.52
	7	.31
	8	.40

TABLE B-11

Point Bi-Serial Correlation Coefficients for All Groupement II Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (8) Groupement II Items	1	.74
	2	.62
	3	.34
	4	.42
	5	.72
	6	.59
	7	.36
	8	.44

TABLE B-12

Point Bi-Serial Correlation Coefficients for All Groupement III Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (8) Groupement III Items	1	.52
	2	.44
	3	.62
	4	.57
	5	.60
	6	.48
	7	.62
	8	.61

TABLE B-13

Point Bi-Serial Correlation Coefficients for All Groupement IV Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (8) Groupement IV Items	1	.66
	2	.65
	3	.60
	4	.63
	5	.68
	6	.68
	7	.46
	8	.51

TABLE B-14

Point Bi-Serial Correlation Coefficients for All Groupement V Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (8) Groupement V Items	1	.62
	2	.57
	3	.65
	4	.62
	5	.58
	6	.50
	7	.43
	8	.45

TABLE B-15

Point Bi-Serial Correlation Coefficients for All Groupement VI Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (8) Groupement VI Items	1	.58
	2	.71
	3	.60
	4	.75
	5	.45
	6	.79
	7	.53
	8	.62

TABLE B-16

Point Bi-Serial Correlation Coefficients for All Groupement VII Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (8) Groupement VII Items	1	.62
	2	.65
	3	.69
	4	.54
	5	.63
	6	.56
	7	.59
	8	.55

TABLE B-17

Point Bi-Serial Correlation Coefficients for All Groupement VIII Items Combining Kindergarten and Third and Sixth Grade Subsamples (N = 180) (Initial Assessment Year's Results)

Subscale	Item	Point Bi-Serial (correlation of item and total subscale score)
All (8) Groupement VIII Items	1	.65
	2	.34
	3	.50
	4	.61
	5	.64
	6	.50
	7	.51
	8	.51

GPO 810-980-2